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Motor Vehicle Tampering Survey — 1985

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MOTOR VEHICLE TAMPERING SURVEY - 1985

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FIELD OPERATIONS AND SUPPORT DIVISION
OFFICE OF MOBILE SOURCES
Washington, D.C.

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INTRODUCTION

Under the direction of the Field Operations and Support Division (FOSD) of the Environmental Protection Agency (EPA), contract personnel from Colorado State University (CSU) conducted a survey of light-duty motor vehicle tampering in 15 cities between April and September, 1985. The areas surveyed and the total number of vehicles inspected are listed below.

Kansas City, MO	469
Kansas City, KS	475
Fresno, CA	466
Charlotte, NC	430
Raleigh, NC	501
Louisville, KY	456
Wilmington, DE	502
Portland, ME	436
Northern Virginia	380
Long Island, NY	305
Philadelphia, PA	446
Cleveland, OH	383
Baton Rouge, LA	438
Houston, TX	450
Albuquerque, NM	449
TOTAL	6,586 vehicles

The objectives of this survey were:

1. To make local measurements of the types and extent of tampering and fuel switching.

2. To extend and update the knowledge gained from earlier surveys on:

   a. The rates of overall and component-specific tampering and fuel switching.

   b. The distribution of tampering by vehicle age, type, manufacturer, and other variables of interest.

   c. The relationship between tampering and vehicle idle emissions.

d. The effect of vehicle inspection and maintenance (I/M) programs and antitampering programs (ATPs) on tampering and fuel switching.

To achieve these objectives, the inspection teams visually examined emission control devices and measured the idle hydrocarbon (HC) and carbon monoxide (CO) emissions of each vehicle. To provide information on fuel switching, the inspectors sampled gasoline from the tanks of vehicles (for later laboratory lead analysis), tested for lead deposits in tailpipes using Plumbtesmo® test paper, and checked the integrity of the fuel filler inlet restrictors. Four categories were used to summarize the condition of the inspected vehicles:

1. Tampered - at least one control device removed or rendered inoperative

2. Arguably Tampered - possible but not clear-cut tampering (i.e., may have resulted from malmaintenance)

3. Malfunctioning

4. Okay - all control devices present and apparently operating properly

These brief but thorough inspections were performed with the consent of the vehicle owners in a variety of settings more fully detailed elsewhere in this report.

While the data from a survey such as this seem to invite inferences regarding program effectivenes, trends, etc., this approach can easily lead to incorrect conclusions. The sample size is reasonably adequate for evaluating tampering prevalence in any particular site, but the sampling of sites is neither

large nor random. Simple comparisons of site tampering rates across control program categories, for example, can overlook a variety of confounding factors. These may include geographical variability, fleet age structure and vehicle mix, variations in program maturity, coverage, history, and management, and the interactions among these factors. Straightforward experimental control of these variables, difficult to achieve under the best of circumstances, becomes impossible in a situation where site selection is driven by programmatic considerations unrelated to the experimental questions.

CONCLUSIONS

For consistency with past surveys, the surveyed vehicles were classified as follows: tampered - 20%; arguably tampered - 27%; malfunctioning - 1%; okay - 52% (overall survey averages). This gross classification, while useful for some comparisons, is less informative concerning the emissions impact of tampering than an examination of component-specific rates. The 20% overall tampering rate is less than the rates found in 1984 and 1983 but greater than the rates from the other large surveys of 1978, 1979, and 1982. The apparent decrease in tampering activity may be an artifact of site-to-site variations in geographic location, truck proportion, and other characteristics, as well as disproportionate selection of sites with I/M and ATP programs. This decline may have emerged in part because this survey's sample is composed of

the 1985 survey. The fuel switching rate weighted by program status was 11%. The pattern of overlap among the three misfueling indicators is discussed in detail later in this report. While the emissions impact of fuel switching depends upon its duration and certain vehicle characteristics, emission increases of 475% for HC and 425% for CO can easily occur.

Age of Vehicle

The probability that a vehicle has been tampered with is clearly related to its age, as has been shown in previous surveys. This is evident in Figure 2, which shows the rates by model year for both overall tampering and catalyst removal. These age-specific rates are investigated more thoroughly later in this report.

Vehicle Types

The tampering rates for light-duty trucks were equal to or higher than for automobiles in every tampering category, as shown in Table 1. The difference in catalytic converter tampering is particularly striking--over twice as prevalent for light-duty trucks as for passenger cars (10% vs 4%). Overall tampering and fuel switching rates among trucks mirror the general decline from 1984 rates observed in the survey as a whole.

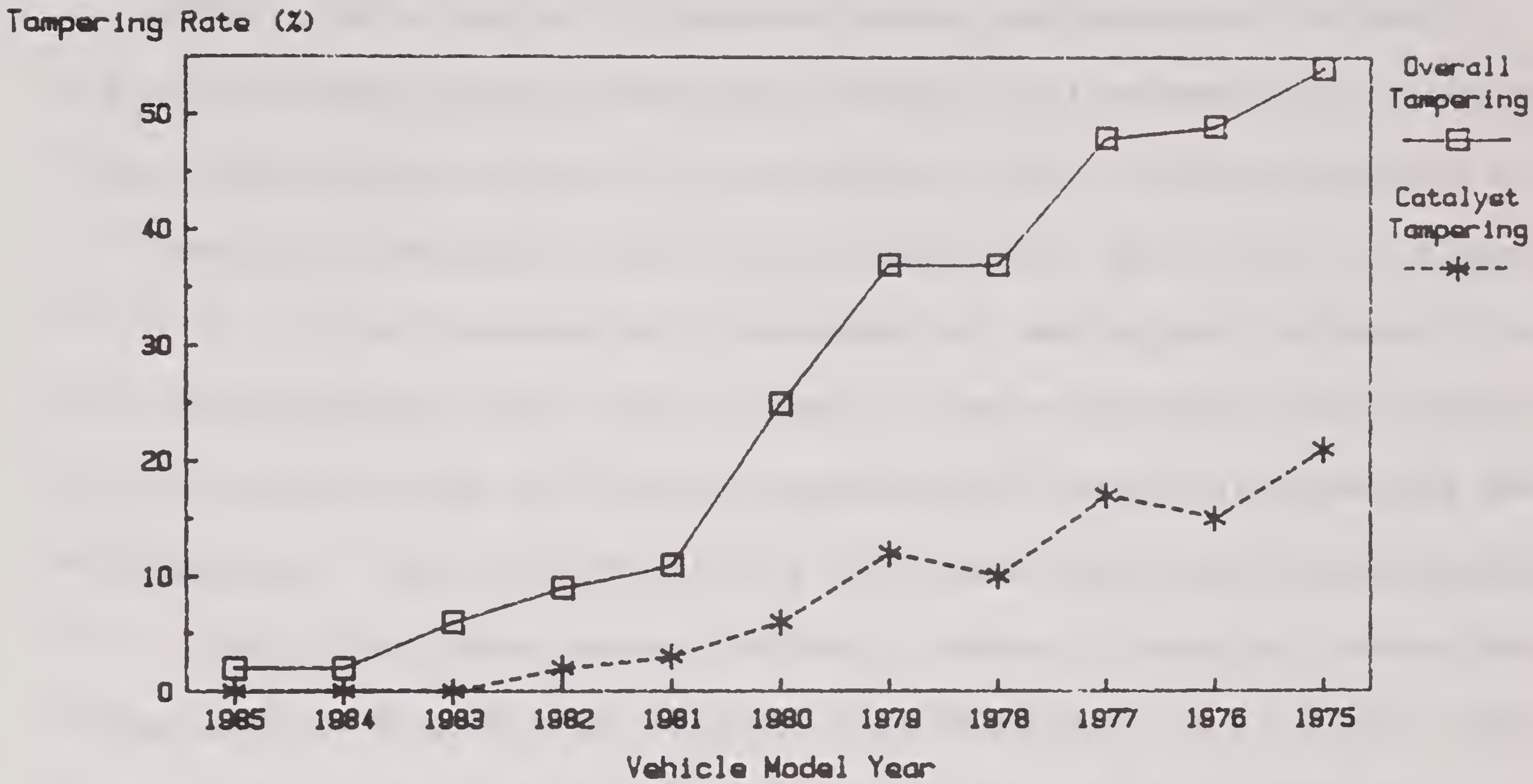

Figure 2. Overall and catalyst tampering by vehicle model year - 1985 survey.

TABLE 1

Tampering Prevalence by Vehicle Type for Critical Control Components

Component/System	Tampering Rate (%) Trucks	Cars	Overall
Catalytic Converter	10	4	5
Filler Neck Restrictor	10	7	7
Air Pump System	11	6	7
PCV System	5	5	5
Evaporative Control System	4	4	4
EGR System	8	7	7
OVERALL	22	19	20
Fuel Switching	13	8	9

I/M Programs and Tampering

While the tampering rates in non-I/M areas were clearly equal to or greater than those with control programs for every critical component, such comparisons across program categories should be made very carefully. The classification of sites into program categories is necessarily somewhat rough. Fresno, for instance, has a biennial I/M + ATP program that has not been in effect long enough for all of the affected vehicles to have been inspected for the first time. Because of restricted program coverage aimed at newer vehicles (those less likely to be tampered with because of warranty status and age) the impact of a newly implemented program may not be observable for several years.

A simple comparison of rates by program status would mislead one to conclude that antitampering programs are of doubtful utility when added onto I/M tailpipe programs. A different picture emerges, however, when we look at a group of sites roughly matched by geographical location, but varying in program status: Raleigh, Louisville, and Charlotte. Raleigh (non-I/M) has the highest rates of the three for catalyst and inlet tampering and fuel switching, followed by Louisville (I/M-only). Charlotte, which shares the geographical background of the other two cities but has an antitampering program augmenting its I/M program, has the lowest tampering rates of the three for the components specified. The effects of control programs on tampering are discussed in greater detail elsewhere in this report.

BACKGROUND

Motor vehicle emissions in urban areas account for nearly 90% of the total carbon monoxide (CO) and airborne lead, over 30% of the hydrocarbons (HC), and nearly 40% of the oxides of nitrogen (NO_x) emitted into the atmosphere. As a result, a major focus of the nation's efforts to achieve compliance with clean air standards has been the control of emissions from mobile sources. The first pollution control devices were installed on vehicles in 1962, and most light-duty vehicles manufactured since 1968 have been equipped with a variety of emission control devices to meet required emissions standards.

The 1977 amendments to the Clean Air Act (sections 203(a)(3)(A) and (B), found in Appendix A) make it illegal for automobile dealers, repair and service facilities, and fleet operators to disconnect or render inoperative emission control devices or elements of design. Regulations issued under section 211(c) of the Act (40 CFR Part 80) prohibit retailers and wholesale purchaser-consumers from introducing or allowing the introduction of leaded gasoline into vehicles labeled "unleaded gasoline only". The EPA's Field Operations and Support Division (FOSD), formerly the Mobile Source Enforcement Division (MSED), is responsible for enforcing the tampering and misfueling provisions of the Act.

Before 1978, the EPA had data suggesting that tampering with emission control devices and misfueling of "unleaded only" vehicles with leaded gasoline was occurring. Variability in the inspection procedures, however, prevented an accurate assessment of the nature and extent of the tampering. As a result, the Agency began conducting nationwide tampering surveys of light-duty motor vehicles in 1978 to determine the rates and types of tampering and fuel switching. These surveys were conducted in 1978[1], 1979[2], 1981[3], 1982[4], 1983[5], and 1984[6], either by FOSD directly, by EPA's National Enforcement Investigations Center (NEIC) under the direction of FOSD, or by EPA contractors supervised by FOSD personnel. Consistent inspection procedures were used throughout these surveys to permit comparisons and identification of trends.

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1 Motor Vehicle Tampering Survey (1978), U.S. Environmental Protection Agency, Mobile Source Enforcement Division, November 1978.

2 Motor Vehicle Tampering Survey (1979), U.S. Environmental Protection Agency, National Enforcement Investigations Center, May 1980, EPA-330/1-80-001.

3 Motor Vehicle Tampering Survey - 1981, Chattanooga, Tennessee and Houston, Texas, U.S. Environmental Protection Agency, National Enforcement Investigations Center, March 1982, EPA-330/1-82-001.

4 Motor Vehicle Tampering Survey - 1982, U.S. Environmental Protection Agency, National Enforcement Investigations Center, April 1983, EPA-330/1-83-001.

5 Motor Vehicle Tampering Survey - 1983, U.S. Environmental Protection Agency, Field Operations and Support Division, August 1984, EPA-460/1-84-001.

6 Motor Vehicle Tampering Survey - 1984, U.S. Environmental Protection Agency, Field Operations and Support Division, October 1985, EPA-460/1-85-001.

The uses for the tampering surveys have evolved since the first survey was conducted in 1978. Since 1983, the tampering survey results for some locations have been used to calculate credits for State Implementation Plans (SIPs), the measures taken by State and local governments to achieve ambient air quality standards by reducing mobile source emissions. Data from the surveys is also used in the default database for the Agency's mobile source computer model (MOBILE3) to estimate both the emissions loading impact and the reductions that may be achieved by various control programs. Sites for the surveys are chosen in light of the need for data on specific areas either currently operating or considering programs, as well as the continuing need to monitor the types and extent of tampering and fuel switching nationwide.

The 1985 tampering survey was conducted for FOSD by the National Center for Vehicle Emissions Control and Safety, Colorado State University (CSU). The inspection procedures used were consistent with those of previous surveys, and are described in detail in the next section of this report.

SURVEY METHODS

The 1985 tampering survey was conducted in 15 cities between April and September, 1985. A goal of inspecting at least 300 vehicles in each location was established to ensure a statistically meaningful database; 6,586 total vehicles were actually inspected. The mix of vehicles inspected was assumed to be a self-weighting sample, and no attempt was made to approximate the national vehicle mix.

Each inspection team consisted of at least four members: three CSU personnel, one or two EPA representatives, and frequently a State or local agency representative. The CSU personnel, assisted by the State or local person, performed the actual inspections, while the EPA representative(s) supervised the survey. Each vehicle inspection included the following:

1. basic vehicle identification data recorded (year, make, model)
2. all emission control systems checked
3. idle HC and CO emissions measured
4. fuel sample collected from unleaded-only vehicles for lead analysis
5. tailpipe tested for lead deposits using Plumbtesmo®[6] test paper
6. integrity of fuel inlet restrictor checked

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[6] Plumbtesmo® is a registered trademark, and appears hereafter without the ®. It is manufactured by Machery-Nagel, Duren, W. Germany, and marketed by Gallard-Schlesinger Chemical Corp., Carle Place, New York.

The inspection and recording procedures are detailed in Appendix B. The survey database has been reviewed by CSU, EPA, and the major automobile manufacturers to ensure its accuracy.

The tampering survey included only 1975 and newer light-duty cars and trucks fueled with gasoline. For the purposes of the tampering surveys, a vehicle is considered to be "unleaded" if a dash label, tank label, or filler inlet restrictor is observed at the time of the inspection. A vehicle's designation as "unleaded" or "leaded" may be changed upon subsequent review of the data. Fuel switching rates are thus calculated based only on the unleaded vehicles surveyed. Similarly, tampering rates for specific components are based only on the vehicles originally equipped with the component.

The inspections were performed with the consent of the vehicle owners at either roadside pullovers or inspection stations. The survey was designed to minimize the refusal rate of potential survey participants. A high refusal rate increases the uncertainty in the data gathered, and individuals who have tampered with or misfueled their vehicles are less likely to allow their vehicles to be surveyed. The overall refusal rate was relatively low (7%), but some

survey sites had high refusal rates (see below). The tampering and misfueling rates at these particular locations might be significantly higher than reported here. A brief description of each survey site follows.

Kansas City, Missouri - non-I/M

Dates:	April 22 - 26, 1985
Vehicles Surveyed:	469
Fuel Samples:	384
Refusal Rate:	9%

The Kansas City Police Department and Missouri State Highway Patrol provided officers to stop potential survey participants, and the inspectors solicited permission to conduct the inspections. Locations for pullovers were changed daily.

Kansas City, Kansas - non-I/M

Dates:	April 29 - May 3, 1985
Vehicles Surveyed:	475
Fuel Samples:	386
Refusal Rate:	5%

Roadside pullovers were conducted with the help of the local law enforcement officers of municipalities in the Kansas City area. Inspection locations were changed daily and included Kansas City (two days), Shawnee, Overland Park, and Olathe.

Fresno, California - I/M + ATP

Dates:	May 20 - 24, 1985
Vehicles Surveyed:	466
Fuel Samples:	297
Refusal Rate:	5%

The California Highway Patrol provided officers to assist with the roadside pullovers. The California Bureau of Automotive Repair conducted a survey of driver's perceptions about emission control concurrently with the tampering inspections. Survey locations were changed daily. Fresno has had a decentralized biennial I/M and antitampering program since November, 1984; consequently less than 30% of the vehicles in Fresno had been inspected at the time of the survey.

Charlotte, North Carolina - I/M + ATP

Dates:	June 3 - 7, 1985
Vehicles Surveyed:	430
Fuel Samples:	324
Refusal Rate:	12%

Roadside pullovers were conducted with the assistance of the Charlotte Police Department. Survey locations were changed daily. Charlotte (Mecklenburg County) enacted an annual decentralized I/M + ATP in December, 1982 which covers the last twelve model years.

Raleigh, North Carolina - non-I/M

Dates:	June 10 - 14, 1985
Vehicles Surveyed:	501
Fuel Samples:	399
Refusal Rate:	7%

The North Carolina Department of Motor Vehicles provided officers to assist with the roadside pullovers. The surveys were conducted at five locations in the Raleigh metropolitan area.

Louisville, Kentucky - I/M-only

Dates:	June 18 - 21, 1985
Vehicles Surveyed:	456
Fuel Samples:	415
Refusal Rate:	7%

The Louisville survey was conducted at four centralized inspection stations in the metropolitan Louisville area. The inspection team set up and conducted the survey at the entrance to the inspection lane each day. The centralized annual I/M program in Louisville (Jefferson County) was enacted in January, 1984.

Wilmington, Delaware - I/M-only

Dates:	June 24 - 28, 1985
Vehicles Surveyed:	502
Fuel Samples:	417
Refusal Rate:	8%

The Wilmington survey was conducted with the assistance of the Delaware State Police, New Castle County Police, and Wilmington Police Department. The roadside pullover locations were changed daily, and were all located in the metropolitan Wilmington area. Wilmington (New Castle County) enacted an annual centralized I/M program in January, 1983.

Portland, Maine - non-I/M

Dates:	July 8-12, 1985
Vehicles Surveyed:	436
Fuel Samples:	376
Refusal Rate:	6%

The Portland survey was conducted at four locations in Portland and one location in South Portland. The inspection team was assisted by the Maine State Police, City of Portland Police, and the South Portland Police.

Northern Virginia - I/M + ATP

Dates:	July 15 - 19, 1985
Vehicles Surveyed:	380
Fuel Samples:	332
Refusal Rate:	10%

The Northern Virginia survey was conducted in the Virginia suburbs of Washington, D.C. The Virginia State Police assisted with the roadside pullovers. Northern Virginia's annual decentralized I/M + ATP was enacted in December, 1981, and covers the previous eight model years.

Long Island, New York - I/M + ATP

Dates:	July 22 - 26, 1985
Vehicles Surveyed:	305
Fuel Samples:	256
Refusal Rate:	12%

The survey was conducted in three New York State counties surrounding New York City: Suffolk, Nassau (2 days), and Westchester. The last day of the survey (in Rockland County) was cancelled because of inclement weather conditions. The New York State Environmental Conservation Police, Long Island Park Police, New York State Police, and Nassau County Police assisted with the roadside pullovers. The greater New York metropolitan area has had an annual decentralized I/M + ATP since January, 1982.

Philadelphia, Pennsylvania - I/M-only

Dates:	August 5 - 9, 1985
Vehicles Surveyed:	446
Fuel Samples:	361
Refusal Rate:	6%

The Philadelphia survey was conducted in Philadelphia four days and in Cheltenham township one day. The Philadelphia Highway Patrol and Cheltenham Township Police assisted with the roadside pullover. The greater Philadelphia metropolitan area has had a decentralized annual I/M program since June, 1984.

Cleveland, Ohio - non-I/M

Dates:	August 12 - 16, 1985
Vehicles Surveyed:	383
Fuel Samples:	343
Refusal Rate:	9%

Roadside pullovers were conducted with the help of local law enforcement officers in the municipalities in the Cleveland area. Inspection locations changed daily and included Cleveland (two days), Parma Heights, Garfield Heights, and Westlake.

Baton Rouge, Louisiana - non-I/M

Dates:	August 19 - 23, 1985
Vehicles Surveyed:	438
Fuel Samples:	405
Refusal Rate:	3%

The Louisiana State Police provided officers to assist with the roadside pullovers. Inspection locations changed daily, and included Baton Rouge, East Baton Rouge, West Baton Rouge, Erwinsville, and Denham Springs. Baton Rouge was a non-I/M area at the time of the survey, but implemented an ATP only in September, 1985.

Houston, Texas - ATP-only

Dates:	August 26 - 30, 1985
Vehicles Surveyed:	450
Fuel Samples:	369
Refusal Rate:	6%

The Houston survey was conducted at four locations in Houston and one location in South Houston. The Texas Department of Public Safety supplied officers to assist with the roadside pullovers. An annual decentralized ATP-only program was implemented in Houston (Harris County) in July, 1984.

Albuquerque, New Mexico - non-I/M

Dates:	September 9 - 13, 1985
Vehicles Surveyed:	449
Fuel Samples:	410
Refusal Rate:	6%

The Albuquerque survey was conducted with the assistance of the New Mexico State Police. Survey locations were changed daily, and included Albuquerque (3 days), North Valley, and South Valley. Albuquerque is currently a non-I/M area, but had an I/M program from January, 1983 to March, 1984.

The frequency distribution of tampering instances for those vehicles classified as "tampered" is also shown in Figure 3. Forty-two percent of the tampered vehicles had multiple components tampered, of which 11% had four or more instances of tampering.

Tables 2 and 3 summarize the 1985 survey data by site. Table 2 is a general survey summary, while Table 3 shows the vehicle condition classification by site. As in the 1984 survey, the overall tampering rates in 1985 vary considerably from site to site. This can be attributed to the variety of program configurations among the cities surveyed and to geographic differences.

Table 2 also contains the refusal rate at each survey site. While the overall refusal rate for the survey was relatively low (7%), three survey sites had refusal rates equal to or exceeding 10%. The actual tampering rates at these sites were probably higher than is reported here, since individuals who tamper with or misfuel their vehicles are less likely to allow their vehicles to be surveyed.

2. Tampering Trends 1978-1985

Table 4 shows the overall rates found in each of the seven tampering surveys. The overall tampering rate declined to 20% from the 22% and 26% rates found in 1984 and 1983, respectively. Such direct comparisons between

TABLE 2

1985 Tampering Survey Summary

Survey Location	Number of Vehicles	Tampering Rate (%)	Misfueling Rate (%)	Survey Type*	Refusal Rate (%)
Kansas City, MO	469	21	10	R	9
Kansas City, KS	475	25	12	R	5
Fresno, CA	466	21	9	R	5
Charlotte, NC	430	19	6	R	12
Raleigh, NC	501	18	14	R	7
Louisville, KY	456	23	10	C	7
Wilmington, DE	502	14	5	R	8
Portland, ME	436	12	5	R	6
N. Virginia	380	15	4	R	10
Long Island, NY	305	20	7	R	12
Philadelphia, PA	446	13	3	R	6
Cleveland, OH	383	22	8	R	9
Baton Rouge, LA	438	32	21	R	3
Houston, TX	450	18	7	R	6
Albuquerque, NM	449	24	11	R	6
OVERALL	6,586	20	9	-	7

*R = roadside pullovers, C = centralized I/M stations,

TABLE 3

Classification of Vehicle Condition by Survey Site

Survey Site	Tampered (%)	Arguably Tampered(%)	Malfunctioning (%)	Okay (%)
Kansas City, MO*	21	24	1	55
Kansas City, KS	25	24	1	50
Fresno, CA	21	31	2	46
Charlotte, NC	19	25	1	56
Raleigh, NC	18	21	1	60
Louisville, KY	23	37	1	39
Wilmington, DE	14	28	2	56
Portland, ME	12	24	2	61
N. Virginia	15	25	1	59
Long Island, NY	20	21	3	56
Philadelphia, PA	13	29	0	57
Cleveland, OH	22	26	2	49
Baton Rouge, LA	32	25	1	42
Houston, TX	18	28	0	53
Albuquerque, NM	24	27	2	47
OVERALL	20	27	1	52

*The rates do not total 100% for some sites because of rounding

TABLE 4

Trends in Vehicle Condition Classification

Survey Year	Tampered (%)	Arguably Tampered(%)	Malfunctioning (%)	Okay (%)
1978	19	48	2	31
1979	18	47	2	33
1981*	14	45	3	38
1982	17	38	1	44
1983	26	30	3	42
1984	22	29	4	46
1985	20	27	1	52

*Because the 1981 survey involved only two sites and a very limited sample size, these results may exhibit more variance than the other larger surveys.

TABLE 5

Comparison of 1985 Survey Sample to Actual Nationwide Vehicle Fleet

Program Type	Percentage within Survey Sample (%)	Approx. Percentage of Nationwide Fleet (%)**
non-I/M	48	75
I/M-only	21	13
I/M + ATP	24	11
ATP-only (Houston)	7	1

** Based on 1986 vehicle population data gathered from EPA Regional and State contacts.

survey years, however, are not entirely appropriate. The surveys, for example, covered different sites, and had different age and car/truck distributions. More importantly, because of the 1985 survey's specific goals, it greatly overrepresents the percentage of the national vehicle fleet under local control programs (see Table 5). I/M and I/M + ATP areas comprised 45% of the survey sample, while only approximately 24% of the national vehicle fleet were under such programs.

This discrepancy can be corrected to some degree by applying a weighting factor to the tampering rates found under each program type. The 1985 tampering rate weighted for program representation is 21%. The 1985 weighted tampering rate can be compared to the weighted rates from the 1984, 1983, and 1982 surveys (26%, 28%, and 19%, respectively.) Applying weighting factors to the 1981 and earlier surveys would be difficult, since some surveys contained no I/M areas. For the sake of clarity, only the actual, unweighted rates found during the surveys will be reported. Useful comparisons, however, can still be made between program types within a given year (e.g., I/M vs. non-I/M) or between the same program type in different years (e.g., non-I/M in 1984 and 1985).

3. Types of Tampering

The tampering rates for specific emission control components and systems for the various survey years are presented in Table 6. The component-specific tampering rates for the 1985 survey are presented by survey site in Table 7. The arguable tampering percentages by component for the 1978-1985 surveys are presented in Table 8. Only those vehicles originally equipped with a particular component are considered when computing the tampering or arguable tampering rate for that component. The heated air intake was the only component that could be classified as either tampered or arguably tampered, based on its condition in a surveyed vehicle (see Appendix B).

Table 6 shows that tampering with some major components (e.g., filler inlet restrictor and catalytic converter) has decreased since the 1984 survey. Tampering with the PCV, aspirator, and evaporative systems has increased since the 1984 survey. Tampering in general remained higher than in the 1982 and earlier surveys.

Table 7 shows the wide variation in tampering rates for any given component from site to site. Catalytic converter removal, for example, ranged from 2% in Fresno to 14% in Baton Rouge. This range is partly due to the effectiveness of I/M and antitampering programs and geographic differences, as will be discussed later in this report.

TABLE 6

Prevalence of Tampering by Component and Survey Year

	Survey Year						
Component/System	1978	1979	1981*	1982	1983	1984	1985
Catalytic Converter	1%	1%	4%	4%	7%	7%	5%
Filler Neck Restrictor	3	4	6	6	7	10	7
Air Pump System	7	5	4	5	7	7	7
Air Pump Belt	6	4	4	5	7	7	4
Air Pump/Valve	3	2	4	4	3	4	6
Aspirator**	***	2	0	1	1	1	2
PCV System	3	3	2	3	5	2	5
Evaporative Control System	3	2	2	2	5	3	4
EGR System	13	10	5	10	13	10	7
EGR Control Valve	12	5	5	7	9	7	6
EGR Sensor	5	7	5	7	12	6	4
Heated Air Intake	1	1	0	1	1	1	1
Vacuum Spark Retard	11	2	1	0	1	5	***
Idle Stop Solenoid	1	1	0	0	1	1	***
Oxygen Sensor	***	***	***	***	0	0	0

*The 1981 survey was of limited scope, covering only two sites and 399 vehicles.

**Vehicles with aspirated air systems are not equipped with other listed air-injection components, nor do conventional systems include aspirators.

***Component not checked during survey.

TABLE 7

Component-Specific Tampering Rates (percent) by Survey Location - 1985 Survey

Survey Location	Emission Control Component or System						
	Catalytic Converter	Inlet Restrictor	Air Pump System	PCV System	EGR System	Evaporative System	Any Component
Kansas City, MO	7	9	6	3	6	3	21
Kansas City, KS	10	10	11	5	11	4	25
Fresno, CA	2	9	4	7	7	4	21
Charlotte, NC	3	5	3	7	8	4	19
Raleigh, NC	8	11	4	2	4	2	18
Louisville, KY	6	8	10	6	6	3	23
Wilmington, DE	3	3	4	4	6	3	14
Portland, ME	4	4	2	2	4	3	12
N. Virginia	1	4	5	3	5	3	15
Long Island, NY	5	4	8	5	6	4	20
Philadelphia, PA	2	2	5	5	5	3	13
Cleveland, OH	6	7	7	7	8	4	22
Baton Rouge, LA	14	17	19	7	14	10	32
Houston, TX	5	5	8	5	9	4	18
Albuquerque, NM	5	9	12	7	6	5	24
OVERALL	5	7	7	5	7	4	20

Table 8 shows that idle limiter caps/sealed plugs remain the item most frequently arguably tampered (42%). The arguable tampering with limiter caps and sealed plugs, however, has continued to decline from a high of 83% in 1981. This is probably due to the widespread use of sealed plugs instead of limiter caps in recent years to deter carburetor adjustments. The sealed plugs are much more difficult to remove than the plastic limiter caps were. Arguable tampering with the heated air intake doubled in 1985, and tank label removal also remained high.

4. Vehicle Characteristics and Tampering

The next section of this report investigates the impact on tampering of three vehicle characteristics: type (car or truck), age, and manufacturer.

Vehicle Type. The tampering prevalence for light-duty trucks was higher than for automobiles, as was mentioned previously (Table 1). The tampering rate for each emissions component on trucks was equal to or greater than on passenger cars, continuing the pattern observed in previous surveys. The catalytic converter tampering rate for trucks was more than double that for automobiles (10% vs. 4%). The fuel switching rate for trucks (13%) was also considerably higher than for automobiles (8%).

TABLE 8

Prevalence of Arguable Tampering by Component and Survey Year

Survey Year	Limiter Cap/ Sealed Plugs	Fuel Tank Cap	Tank Label	Dash Label	Heated Air Intake
1978	65%	0%	5%	1%	9%
1979	62	1	4	1	8
1981	83	1	4	0	9
1982	54	2	4	1	6
1983	54	3	9	1	14
1984	49	1	12	3	8
1985	42	1	10	2	16

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1979	62	1	4	1	8
1981	83	1	4	0	9
1982	54	2	4	1	6
1983	54	3	9	1	14
1984	49	1	12	3	8
1985	42	1	10	2	16

Vehicle Age. Table 9 relates vehicle age and model year with tampering prevalence for the 1978-1985 surveys. Catalytic converter removal rates are similarly related to vehicle age and model year in Table 10. The results from any given survey are entered diagonally in each table.

The results in Tables 9 and 10 indicate that vehicle tampering increases directly with vehicle age. Examining Table 9 diagonally (by survey) shows a fairly linear increase in the tampering rate with vehicle age for each survey. In the 1985 survey, for example, the tampering rate increases from 2% for first year (1985) vehicles to 54% among the 1975 model year vehicles surveyed. Table 10 shows a similar, though less pronounced, increase in catalyst removal. Examining these tables in this manner has the advantage of comparing data collected during one survey in one set of locations, but ignores the possible effects of model year differences (i.e., technology) on tampering.

Two additional ways of analyzing Tables 9 and 10 address the impact of model year on tampering rates. Analyzing the tables horizontally (holding the model year constant) provides a look at the tampering rates over time for the vehicles of a particular model year. This approach shows the same distinct increase in tampering with vehicle age for all model years since 1975. (The 1974 and 1973 data sets are too small to

TABLE 9

Tampering Percentage (and Sample Size) by Model Year and Vehicle Age at Time of Survey

	Year of Vehicle Life										
Model Year	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh
1985	2(816)										
1984	1(462)	2(1001)									
1983	7(182)	4(471)	6(710)								
1982	1(250)	4(226)	7(466)	9(621)							
1981	2(57)	7(448)	13(206)	15(458)	11(607)						
1980		5(63)	9(454)	15(211)	18(516)	25(564)					
1979	6(371)		9(59)	18(477)	31(288)	28(503)	37(673)				
1978	7(298)	14(502)		15(79)	21(430)	39(238)	34(559)	37(562)			
1977		10(457)	15(476)		21(66)	26(316)	44(190)	41(408)	48(452)		
1976			18(395)	19(374)		29(52)	26(317)	40(171)	39(385)	49(369)	
1975				22(274)	22(271)		32(22)	37(183)	55(89)	46(197)	54(194)
1974					33(276)	27(242)					
1973						32(253)	36(251)				

TABLE 10

Percentage of Catalyst Removal (and Sample Size)
among Catalyst-equipped Vehicles by Model Year and Vehicle Age at Time of Survey

	Year of Vehicle Life										
Model Year	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh
1985	0(808)*										
1984	0(462)	0(978)									
1983	1(179)	2(471)	0(686)								
1982	0(250)	1(225)	2(465)	2(597)							
1981	0(57)	2(441)	5(204)	6(457)	3(567)						
1980		2(61)	2(428)	3(200)	6(487)	6(522)					
1979	0(326)		4(55)	6(429)	12(252)	10(455)	12(572)				
1978	0(291)	0(445)		0(71)	4(362)	8(213)	8(486)	10(472)			
1977		1(417)	1(417)		2(59)	2(271)	11(166)	14(357)	17(379)		
1976			2(377)	2(305)		10(48)	6(257)	12(139)	12(314)	15(291)	
1975				2(242)	2(204)		26(19)	12(139)	23(75)	16(174)	21(130)

*Tampering rates have been rounded to the nearest whole percent. A zero does not necessarily indicate a total absence of tampering, but rather a level of tampering that rounded to zero.

permit any conclusions.) For example, the tampering incidence for 1979 vehicles increased from 6% in their first year to 37% by their seventh year of use. This increase in tampering with vehicle age also seems to lessen once the vehicles of a model year are five years old or more, with the tampering rates leveling off at higher levels in older model years. This type of analysis involves observations made from different survey sites at different times; nevertheless, the relationship between tampering rate and vehicle age is readily apparent.

Tables 9 and 10 can also be analyzed vertically (holding vehicle age constant), which provides a look at the tampering rates for different model year vehicles of the same age. This approach suggests that improvements in automotive technology, such as closed loop emission control systems, may initially affect overall tampering rates. Vehicle tampering by the second year, for example, was only 2% for 1984 vehicles compared to 10% for 1977 vehicles. A similar vertical analysis of Table 10, however, shows that catalytic converters are as susceptible to tampering on newer models as on older ones at a given vehicle age. Vertical analysis of Tables 9 and 10 introduces the same variability as the horizontal analysis.

The influence of vehicle age on tampering can be more clearly seen when the data in Tables 9 and 10 is presented graphically. Figures 4 and 5 plot the overall and catalyst

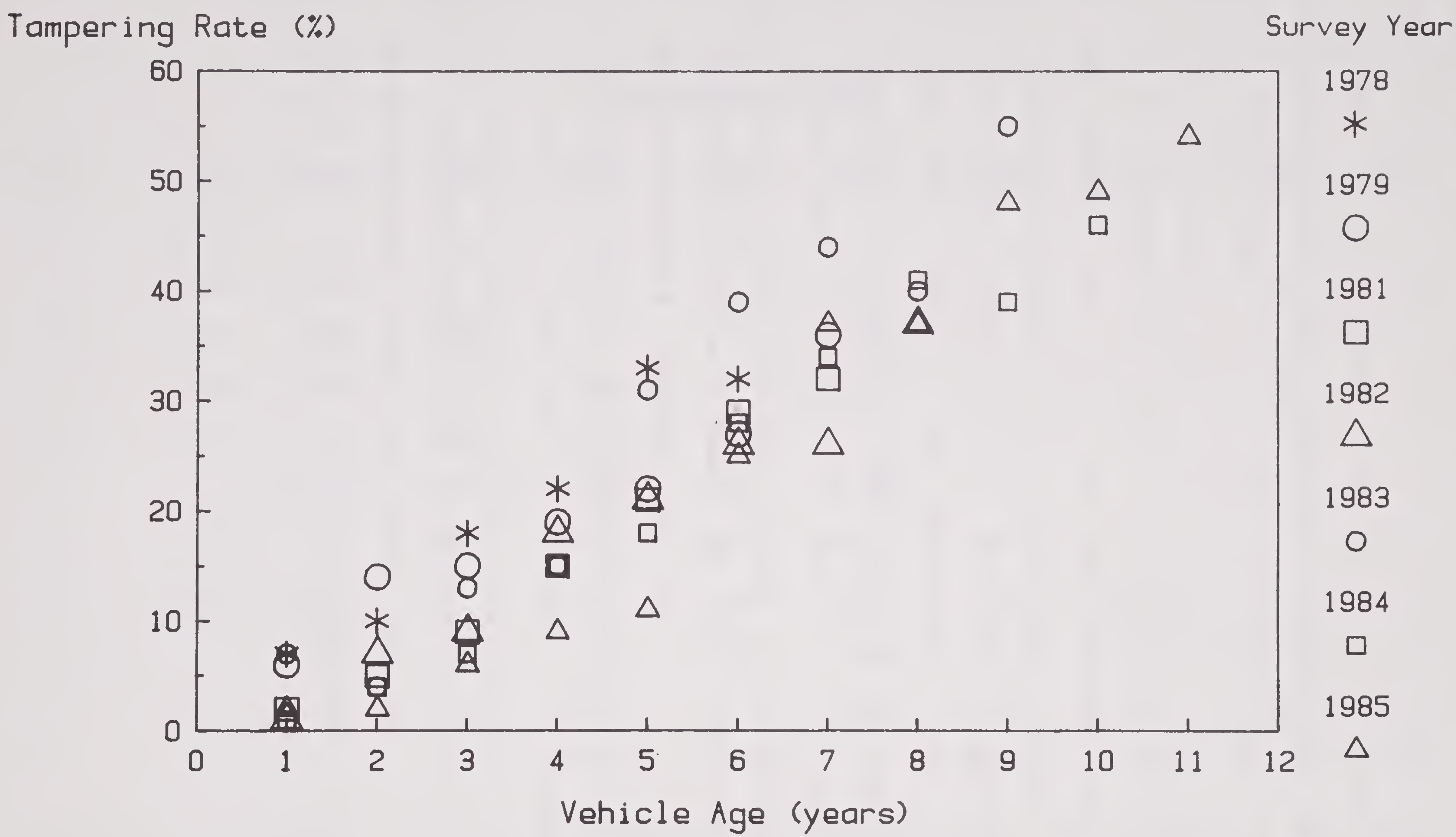

Figure 4. Cumulative tampering prevalence as a function of vehicle age for the 1979 - 1985 surveys.

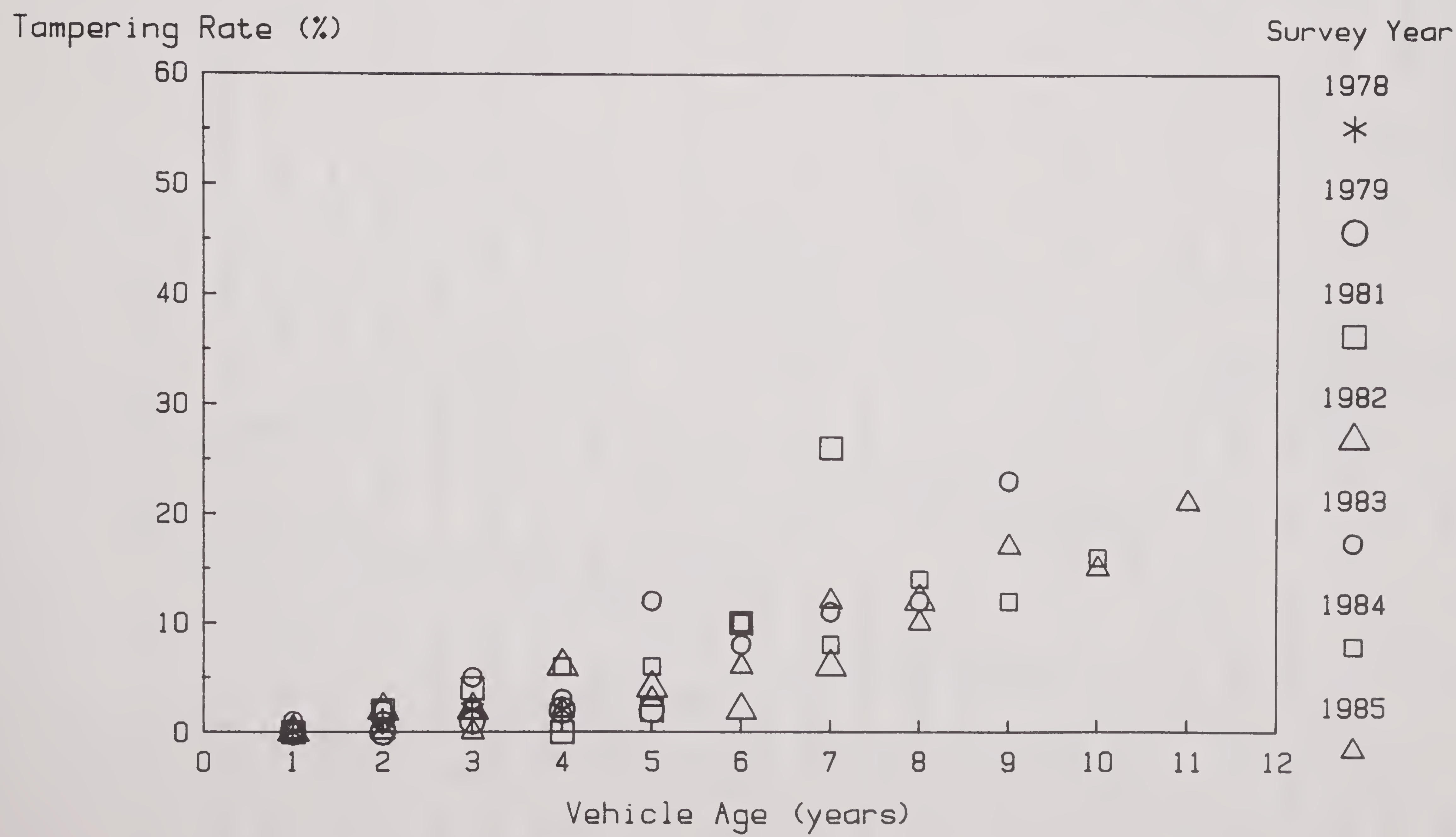

Figure 5. Cumulative catalyst tampering rate as a function of vehicle age for the 1978 - 1985 surveys.

tampering rate, respectively, as a function of vehicle age for the 1978-1985 surveys. This is equivalent to the diagonal method of analysis used for Tables 9 and 10 that was outlined previously. Figure 4 demonstrates that the relationship between tampering rate and vehicle age is not only linear, but has remained nearly constant since the first survey in 1978. The strong correlation is obvious despite the different sizes, vehicle compositions, and locations of the surveys. In Figure 5 the catalyst tampering rate remains negligible for the first two to three years of a vehicle's life, and then increases thereafter. This delay in catalyst tampering is understandable, since the emission control components on all new vehicles are warranted for 5 years/50,000 miles by the manufacturer, providing an incentive to maintain the catalysts on vehicles still under warranty. A similar delay in overall tampering would also be expected, but is not readily apparent in Figure 4.

The link between tampering prevalence and vehicle age was shown to influence the survey averages for tampering in the 1984 report. Previous survey samples have been comprised of increasingly older vehicles, contributing to the increase in overall tampering among surveyed vehicles. Figure 6 shows that the proportion of older vehicles (five or more years old) in the survey declined in 1985 for the first time, down to 52% from a high of 58% of the vehicles surveyed in 1984.

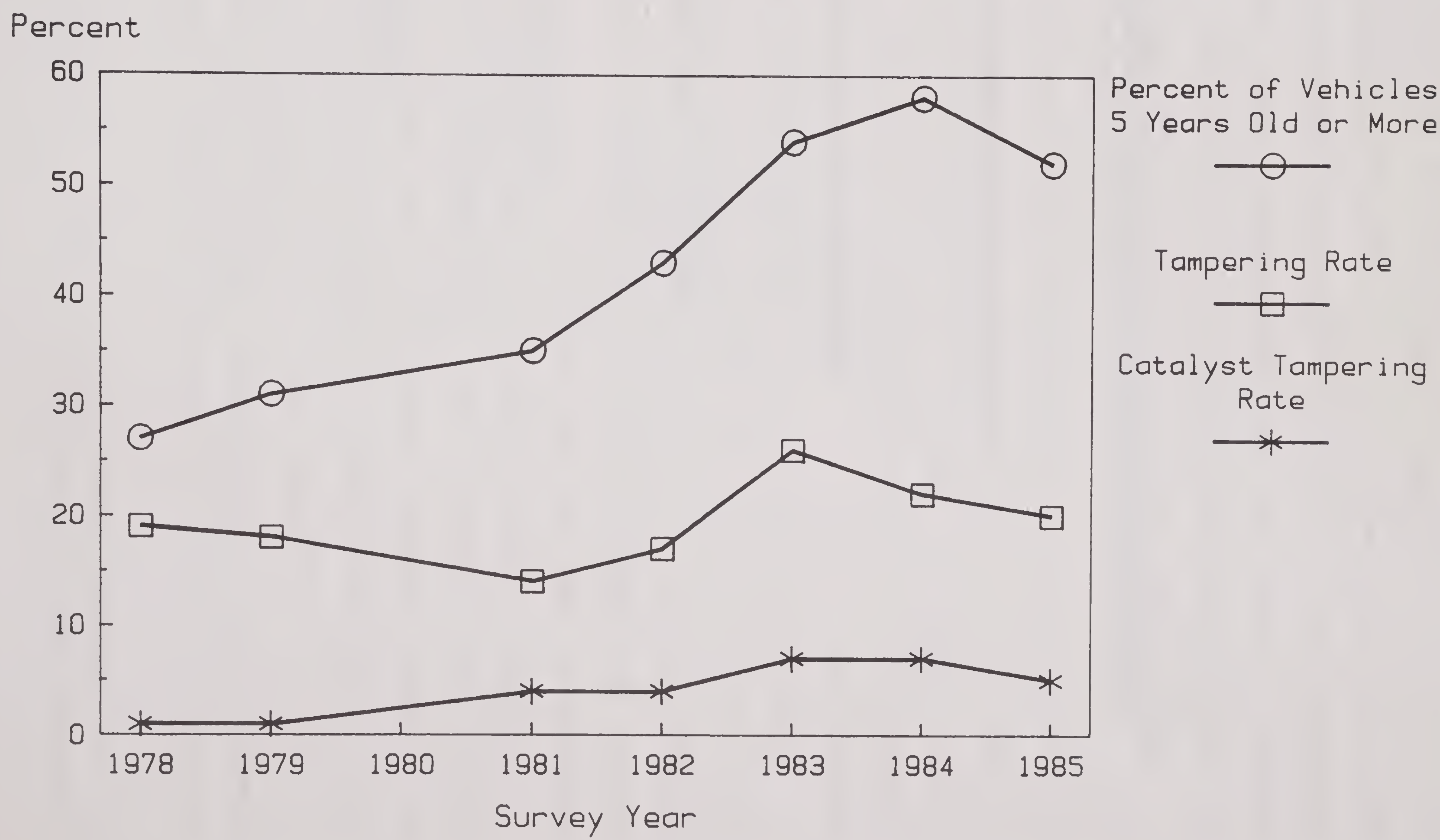

Figure 6. Comparison of catalyst and overall tampering rates with vehicle age as a function of survey year.

This decline may represent a stabilizing of the proportion of older vehicles surveyed, since the 1985 survey population encompassed 82% of the cars and 74% of the light-duty trucks currently in use.[2] The lower proportion of older vehicles in the survey may have thus contributed to the decline in tampering.

Manufacturer. Figure 7 presents the 1985 tampering rates for each major manufacturer. Since the number of vehicles surveyed for each individual foreign manufacturer is small, foreign vehicles have been combined into two groups, European and Japanese. As in previous surveys, the tampering rate is higher among domestic than foreign manufacturers.

Figure 8 shows the trend in tampering rates for each manufacturer over time. The American vehicles are at or consistently above the overall tampering rate, while the European and Japanese vehicles have a tampering incidence consistently lower than the overall rate.

A number of factors might explain the discrepancy in tampering among manufacturers. Differences in design may make some vehicles more tamper-prone than others. Changing market share history results in different age distributions for vehicles of different makes, and vehicle age is clearly related to tampering prevalence. Tampering rates probably vary with geographic location and socioeconomic background,

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2 based on model year distribution data used in MOBILE3.

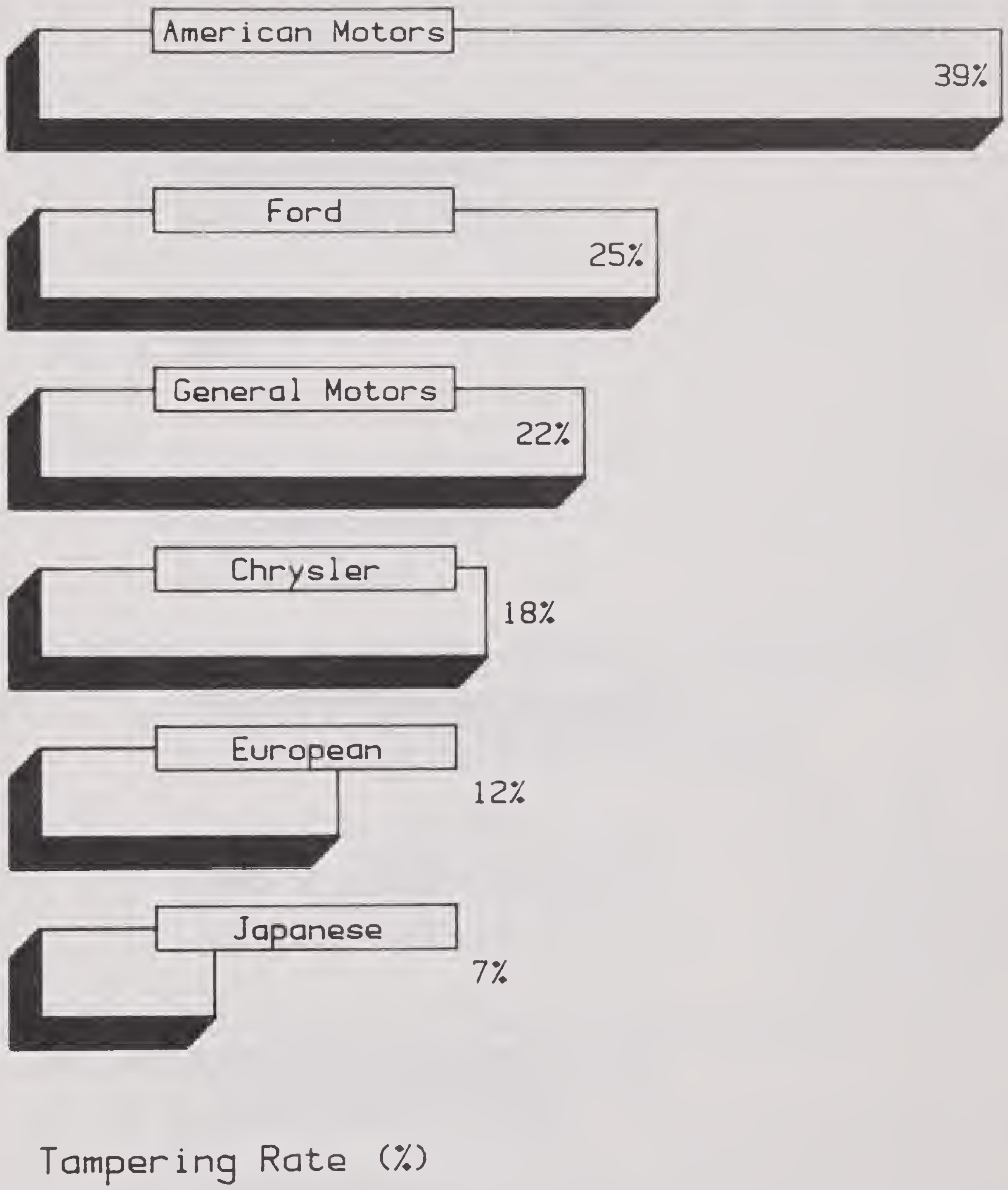


Figure 7. Tampering rates by manufacturer - 1985 survey.

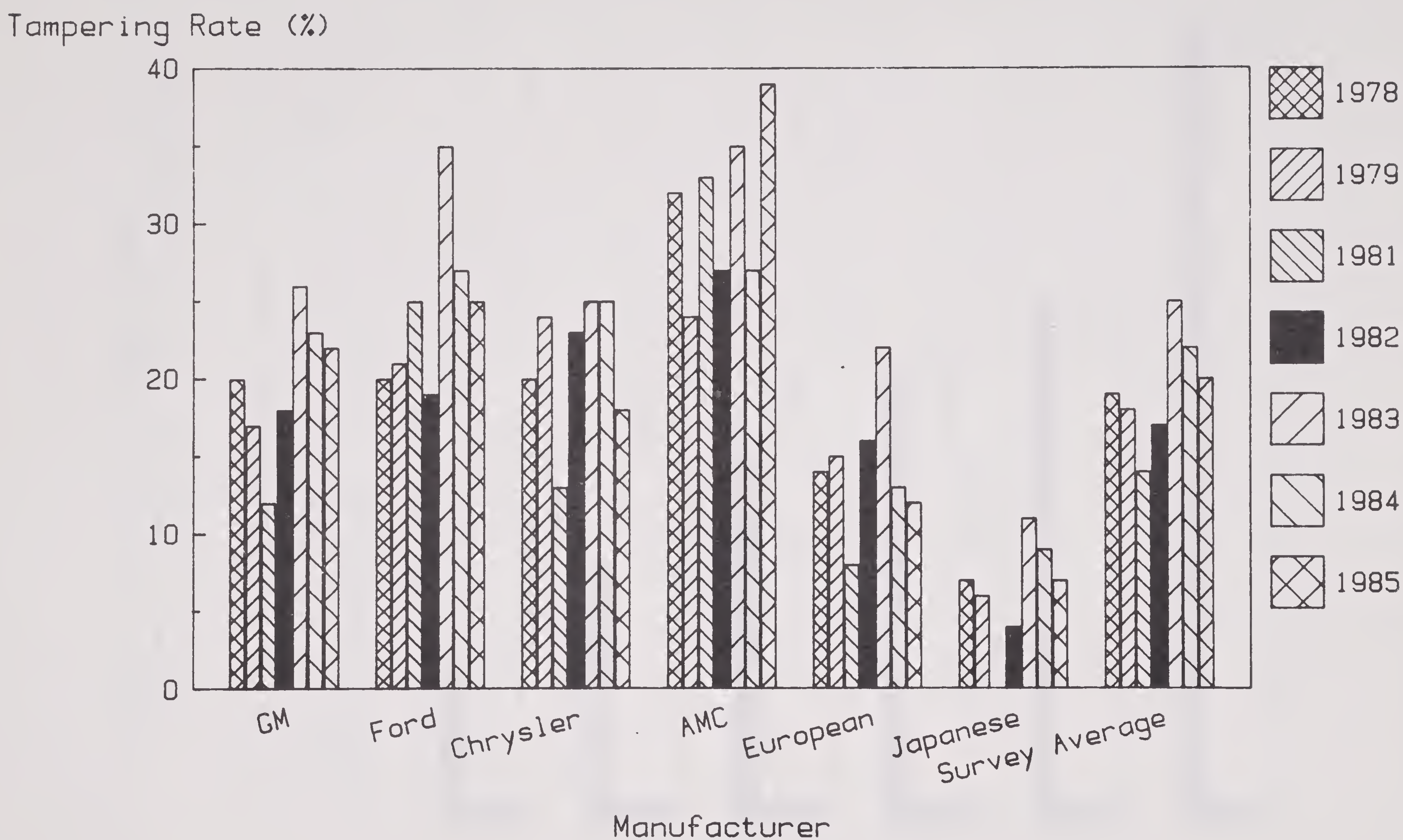


Figure 8. Tampering prevalence by manufacturer for the 1978 - 1985 surveys.

so the owner demographics for different makes may affect the likelihood of tampering. Finally, certain types of vehicles (trucks, for instance) are more likely to be tampered, and thus manufacturers with production concentrated in these types can be expected to have higher tampering rates.

5. <u>I/M Programs and Geographic Bias</u>

Before examining the impact of I/M and antitampering programs on tampering and misfueling, the influence of geography on the survey data should first be discussed. Previous surveys have shown that tampering is historically higher in southern states than in northern states, which complicates any evaluation of I/M and antitampering program effectiveness. To illustrate this phenomenon the 1985 survey sites are listed below by program type.

Non-I/M	I/M-Only	I/M + ATP
Kansas City, MO	Louisville, KY	Fresno, CA
Kansas City, KS	Wilmington, DE	Charlotte, NC
Raleigh, NC	Philadelphia, PA	Northern Virginia
Portland, ME		Long Island, NY
Cleveland, OH		
Baton Rouge, LA		
Albuquerque, NM		

The sites for the 1985 survey are fairly well distributed geographically among program types, lessening any geographic bias. The influence of geography can still be seen, however, in the tampering rates for the 1985 survey sites. The three areas surveyed with the lowest tampering rates were all northern cities (Portland, Philadelphia, and Wilmington).

Portland's low tampering rate (12%) is particularly noteworthy because it is a non-I/M area, and its tampering rate was considerably less than was found in Louisville (23%), a southern I/M area, and Baton Rouge (32%), a southern non-I/M location.

One way to minimize geographic bias when evaluating program effectiveness is to compare programs within the same geographic region. Figure 9 compares catalyst tampering and fuel switching in three southern cities with different program types - Raleigh (non-I/M), Louisville (I/M-only), and Charlotte (I/M + ATP). This data shows that when geographic bias is minimized the effectiveness of I/M and I/M + ATP becomes apparent. While such comparisons as these overlook other variables such as program design and administration, the geographical location of a survey site is nonetheless a contributing factor to an area's tampering prevalance.

6. Effect of I/M Programs on Tampering

Inspection and maintenance (I/M) programs require vehicles to meet specific idle emission standards. Vehicles registered in areas with these programs are required to be periodically tested to assure that they comply with the specific idle emission cutpoints established by these jurisdictions. In addition to reducing emission levels by stimulating better owner maintenance, I/M programs may deter some tampering with emission control components. Data from previous surveys has

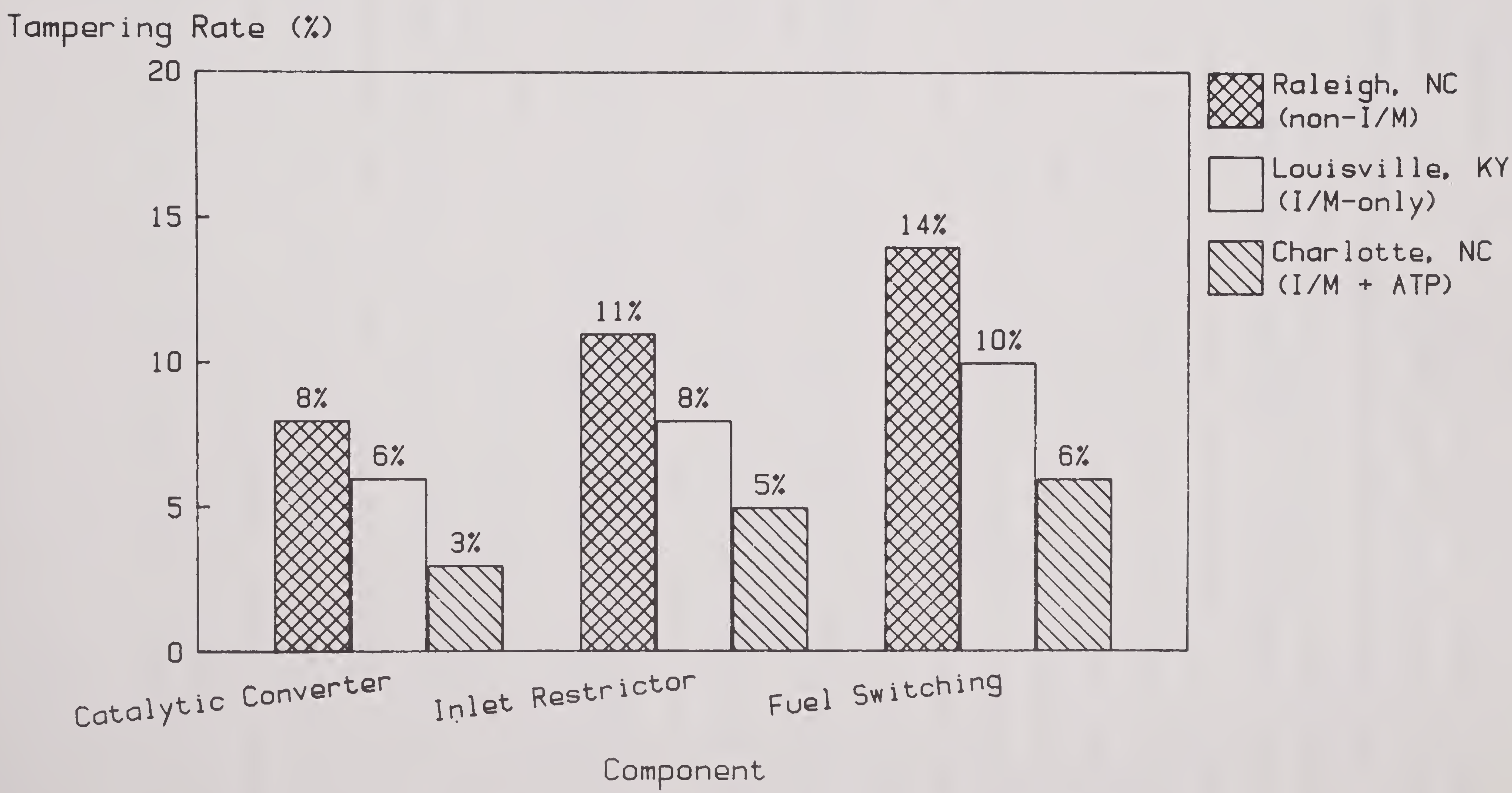


Figure 9. Comparison of tampering found in three locations in the same geographic region - 1985 survey.

tended to support this proposition, since tampering in I/M areas has historically been lower than in non-I/M areas.

Some I/M areas have also instituted antitampering programs (ATPs), which involve periodic vehicle inspections to check the integrity of specific emission control components. Antitampering programs vary greatly in the components inspected and the vehicle model years covered, so that a vehicle or component which would be inspected in one program area might not be inspected in a different program area. Successful antitampering programs should reduce existing tampering and deter future tampering with the components and model years covered by the program.

Throughout this report the survey sites are classified very generally as seven non-I/M areas, three I/M-only areas, four I/M + ATP areas, and one ATP-only area (Houston). Houston was the only city in 1985 to have an antitampering program and no I/M program; similar programs, however, were implemented in other areas in January, 1986. The survey results from Houston will be discussed separately from the other survey sites.

Table 11 compares the tampering rates in non-I/M, I/M-only, and I/M + ATP areas to earlier surveys. The tampering rates in non-I/M areas are considerably lower than in the previous two surveys, while tampering in I/M + ATP areas is higher than in previous surveys. It thus appears from the data for this particular survey that I/M programs and I/M + ATPs are

TABLE 11

Tampering Prevalence in I/M and non-I/M Areas

Survey Year	Tampering Rate (%) non-I/M	I/M-only	I/M + ATP	Overall
1978	19	*	*	19
1979	20	13	*	18
1981**	14	*	*	14
1982	19	15	10	17
1983	29	24	16	26
1984	31	17	11	22
1985	22	17	19	20

*none surveyed
**1981 survey was of limited scope, covering only two sites and 399 vehicles

TABLE 12

Component-Specific Tampering by Inspection Program Type - 1985 Survey

Component	Tampering Rate (%) non-I/M	I/M-only	I/M+ATP
Catalytic Converter	8	3	2
Inlet Restrictor	9	5	6
PCV System	5	5	6
Air Pump System	9	6	4
Evaporative System	4	3	4
EGR System	8	6	7

only slightly more effective than no I/M program at all. Similar results are reflected in the 1985 component-specific tampering rates for each program type, as shown in Table 12. These observations are not due to any decrease in program effectiveness, but rather to the generalizations inherent in the way programs are categorized in this survey.

Tampering programs vary generally in their model year and component coverage. Long Island, for example, is classified as an I/M + ATP site because 1984 and newer vehicles are subject to an antitampering inspection. Vehicles manufactured between 1975 and 1983, however, are subject only to an I/M test. Long Island is thus predominantly an I/M-only site. Also, all emission control components are not covered by the I/M + ATP inspection programs. For example, Charlotte does not inspect the evaporative system. Finally, Fresno is classified as on I/M + ATP area even though the tampering survey was conducted only six months after the start of a biennial inspection program.

As this discussion suggests, the I/M + ATP rates reported above do not accurately reflect actual program effectiveness in controlling tampering with particular components in covered model years. In order to more appropriately assess the effectiveness of tampering inspection programs, the catalyst tampering rate will be analyzed. It is appropriate to focus on the catalyst rate for several reasons. The catalyst is the primary HC and CO emission control component and thus

represents the largest portion of the emission benefit attributable to tampering inspection programs. Also most of the survey vehicles were originally equipped with catalysts.

Table 13 presents the model year specific and overall catalyst tampering rates for non-I/M, I/M only and I/M + ATP areas. All out-of-state vehicles were excluded from the I/M and I/M + ATP figures because those vehicles are not subject to the local programs. The New York vehicles were split by model year with the 1984 and newer vehicles appearing in the I/M + ATP rates and the 1975 to 1983 vehicles in the I/M only rates. To show the program impacts graphically, regression techniques were used to fit a separate power curve for each program type to the date in Table 13. These curves are presented in Figure 10.

Figure 10 and Table 13 suggest that, for the sites surveyed, I/M and I/M + ATP areas have lower catalyst rates than non-I/M areas. The deterrence and correction of tampering in I/M + ATP areas is also readily apparent.

7. Tampering Trends for Selected Sites

The impact of I/M and antitampering programs in specific locations can be examined by comparing the 1985 survey data with that from earlier surveys. Comparisons made between surveys widely spaced in time, however, must take into consideration the differences in average vehicle age in each survey. The average miles traveled per vehicle surveyed in 1985, for example, is 62% greater than it was in the 1978

TABLE 13

Catalyst Tampering among Vehicles for each Model Year Covered by a Particular Program Type

Vehicle Model Year	Tampering Rate (%) for each Program Type non-I/M	I/M-only	I/M+ATP
1985	0	0	0
1984	0	1	0
1983	1	0	0
1982	2	2	1
1981	4	2	0
1980	9	4	2
1979	17	7	4
1978	14	7	4
1977	25	9	3
1976	22	12	2
1975	32	13	10
TOTAL	8	4	1

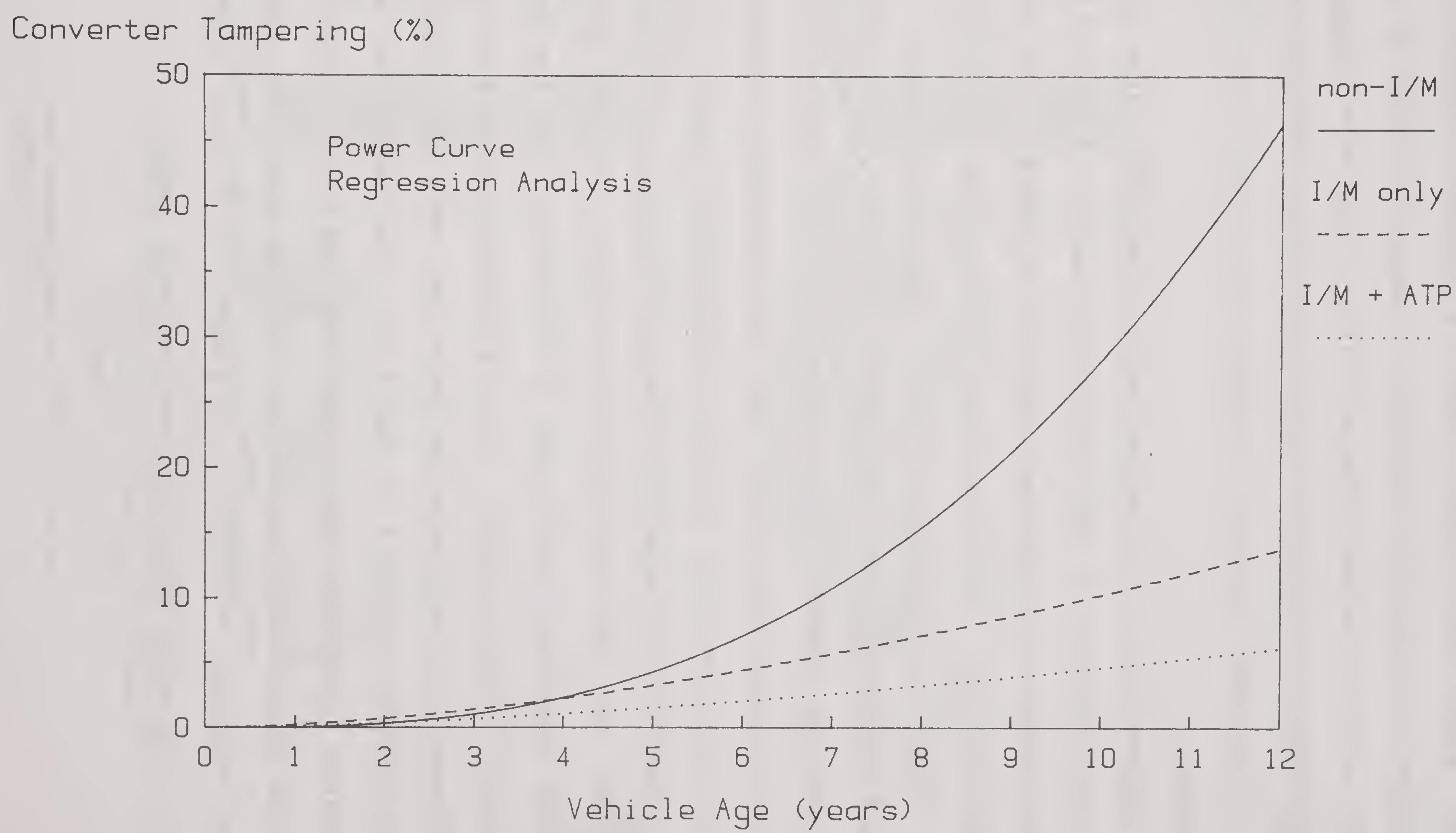
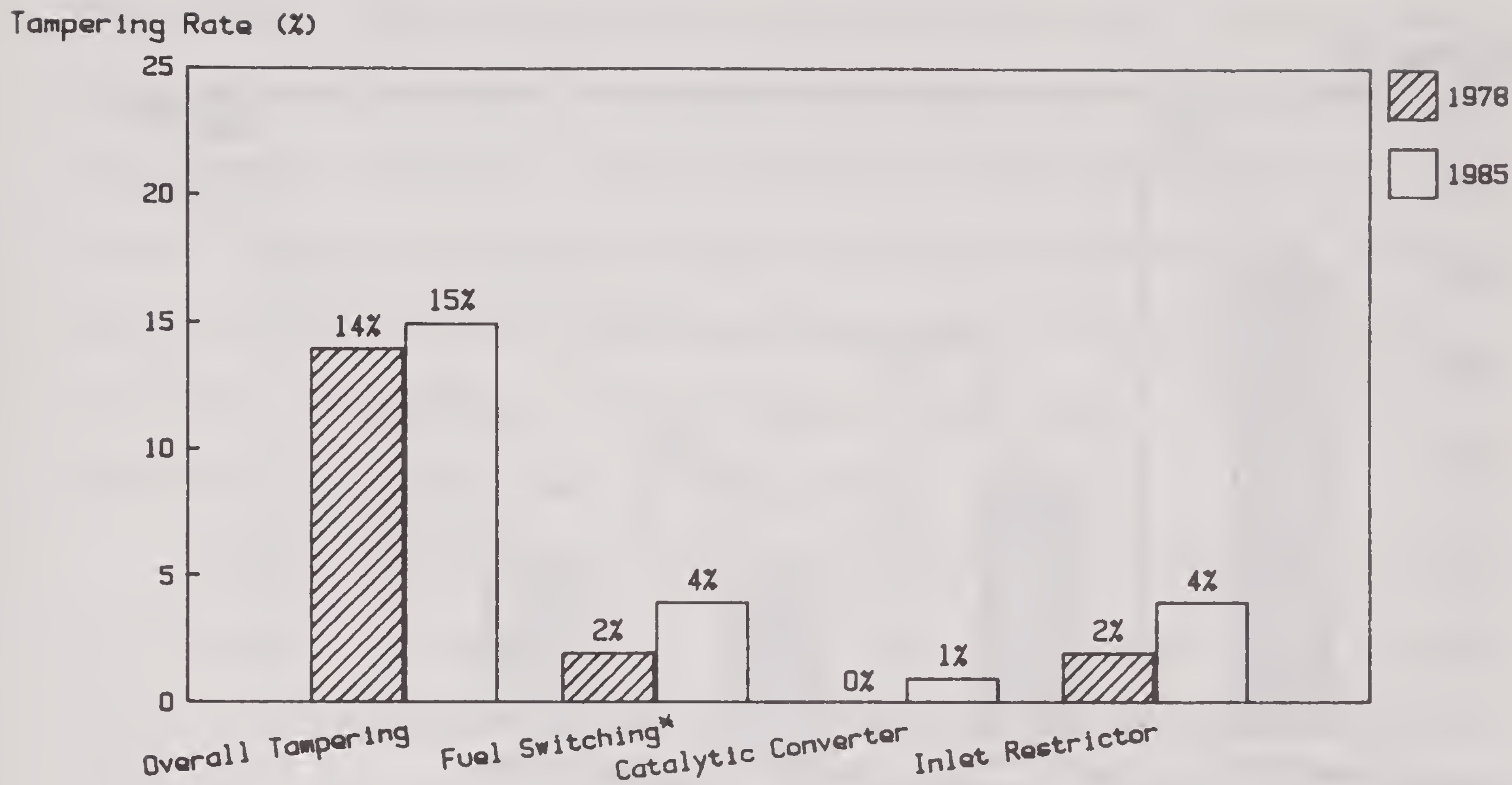


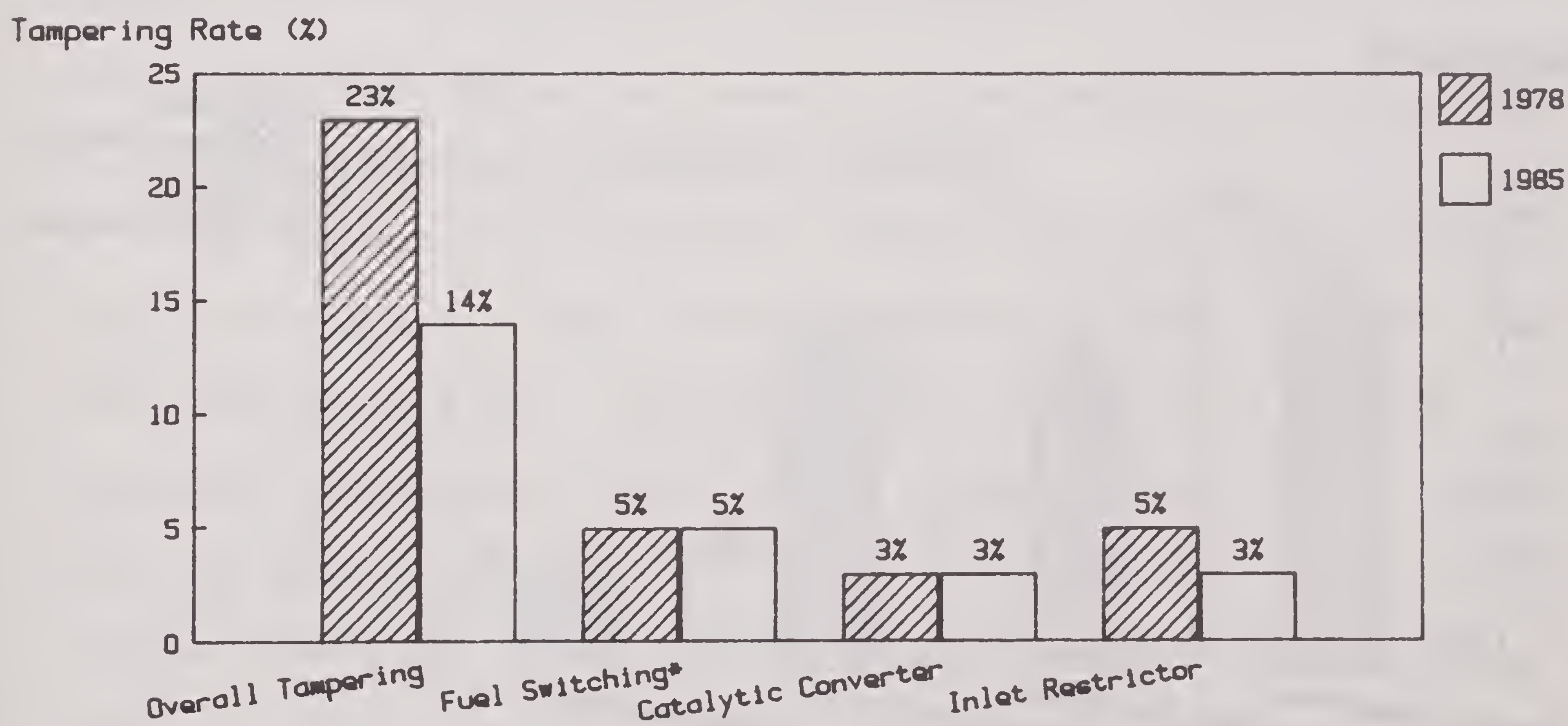
Figure 10. Converter tampering as a function of vehicle age for vehicles covered by different programs - 1985 survey.

survey. Since vehicle age is directly related to tampering prevalence, a substantial increase in tampering might be expected to have occurred between 1978 and 1985, if all other factors remain constant (car/truck distribution, owner demographics, etc.) Inferences regarding program effects must thus be made cautiously.

Figures 11(a)-11(d) depict overall tampering rates for four sites surveyed in 1985 and earlier years. Figure 11(a) compares tampering in northern Virginia as found in the 1978 and 1985 surveys. In 1978 northern Virginia was a non-I/M area. Figure 11(a) suggests that low tampering rates in northern Virginia predate the advent of an I/M + ATP, and that there has been essentially no change in overall tampering in northern Virginia since 1978. When the increase in average vehicle miles from 1978 to 1985 is considered, however, it is quite possible that tampering rates in Virginia in 1985 are much lower than they would have been without a control program. A similar comparison can be made in Wilmington over the same time period (Figure 11(b)). In 1978 Wilmington was also a non-I/M area, but had tampering rates that were much higher than in northern Virginia at that time. The institution of an I/M program in Wilmington has apparently had a significant impact on overall tampering, since the 1985 rates (for higher mileage vehicles) in Wilmington are equal to or lower than they were in 1978, when vehicle mileage was much lower.



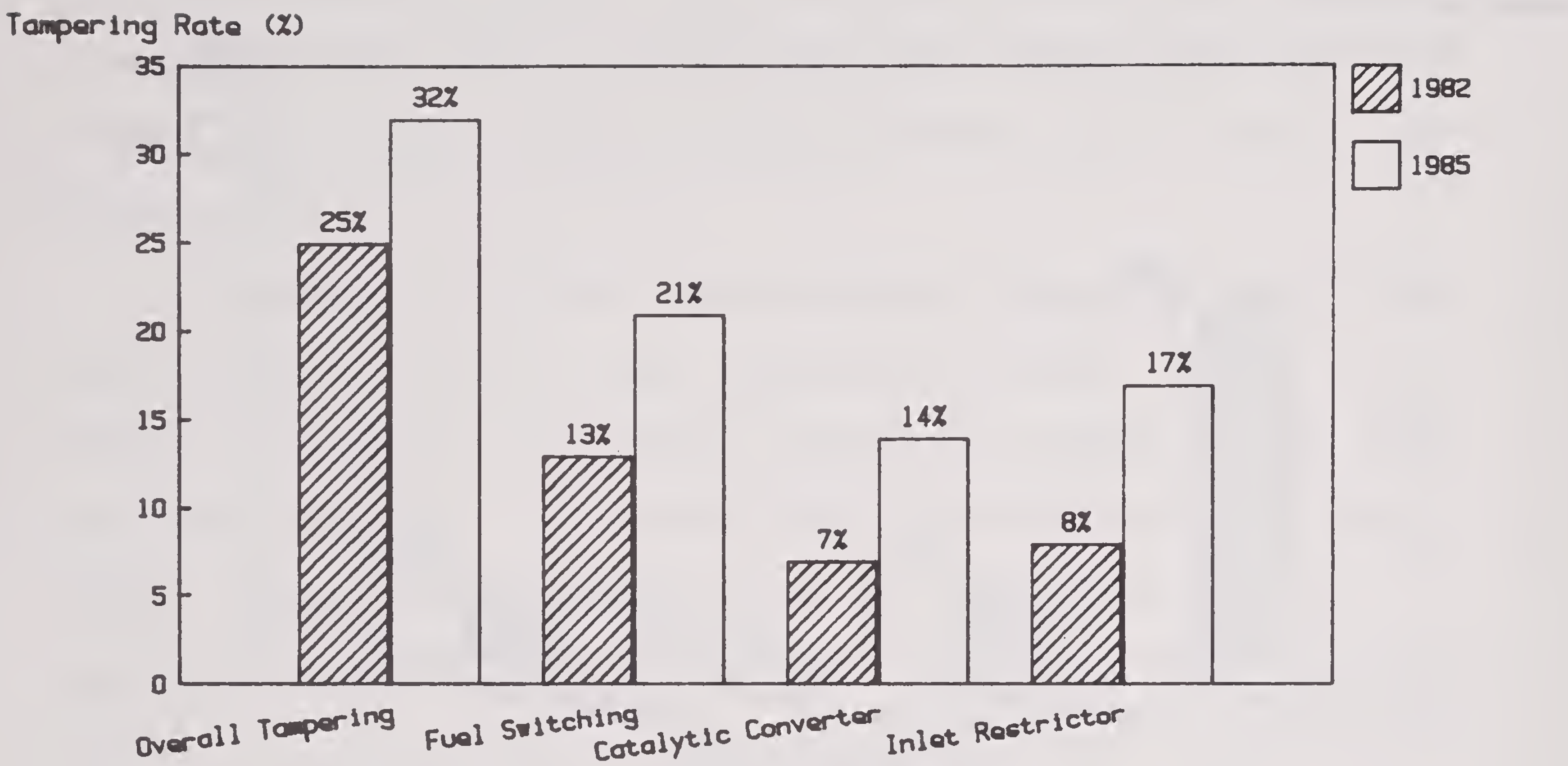
a) Northern Virginia



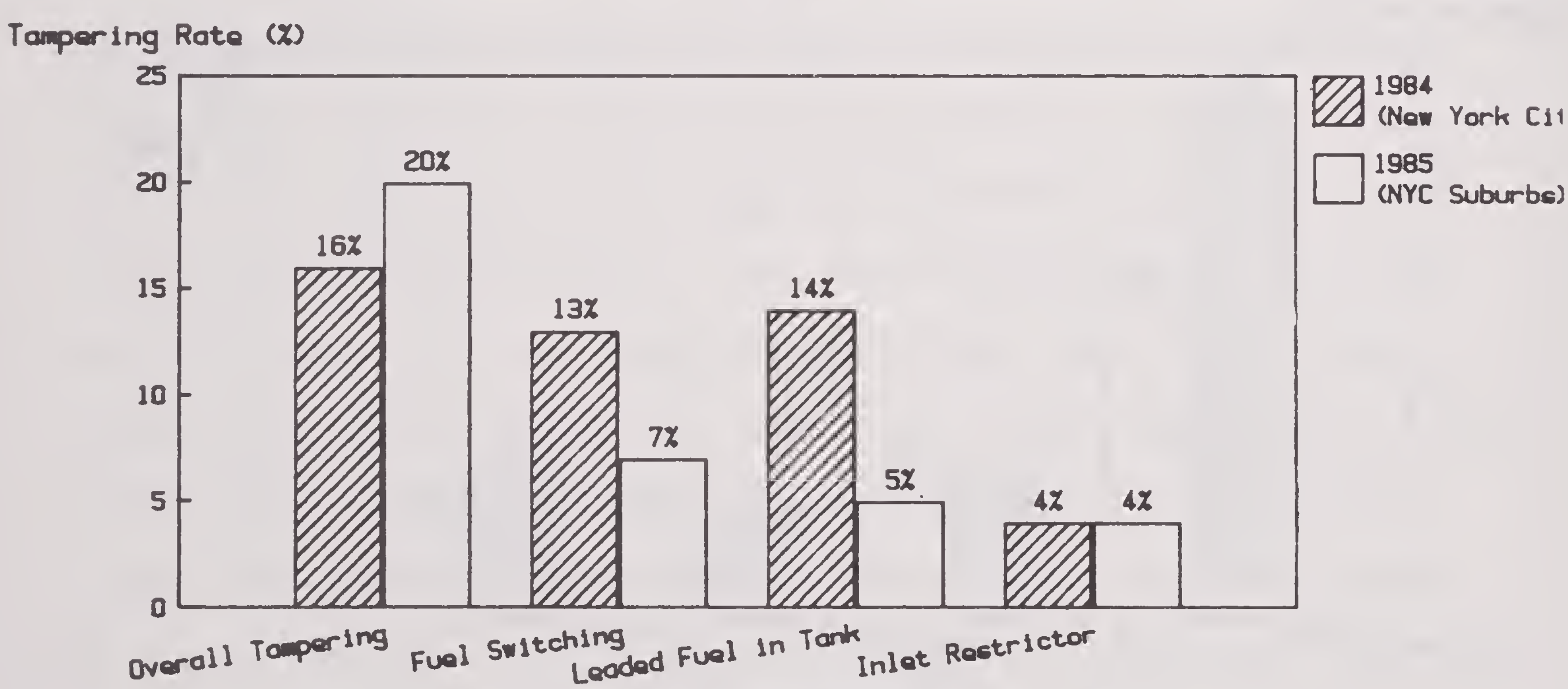
b) Wilmington, DE

Figures 11(a) and (b). Comparison of data from 1985 survey sites that had been surveyed previously.

*Fuel switching rates in 1978 do not include plumbtesmo results



c) Baton Rouge, LA



d) New York Metropolitan Area

Figures 11(c) and (d). Comparison of data from 1985 survey sites that had been surveyed previously (cont'd).

Baton Rouge was surveyed in 1982 and 1985, and the results from those surveys can be found in Figure 11(c). Baton Rouge has always been a non-I/M area, and Figure 11(c) depicts a substantial increase in tampering in the absence of any control program. This difference may also in part be due to the higher average mileage of surveyed vehicles in 1985 than in 1982, and the greater proportion of trucks surveyed in 1985. Baton Rouge instituted an ATP-only in September, 1985, and is scheduled to be surveyed in 1986.

Figure 11(d) shows the survey results for New York City in 1984 and its suburbs in 1985. The most interesting aspect of this comparison is the large decrease in the percent of vehicles with leaded fuel in their tanks. This may be attributed to a concentrated Agency and local effort to curb widespread unleaded gasoline contamination in the New York City area last year.

8. Effectiveness of ATP-Only - Houston

As was mentioned earlier, Houston (Harris County) was the first area to adopt an antitampering program without an idle emissions test. Started in July, 1984, this program includes a tampering check of the PCV, evaporative, air pump, and EGR systems for 1975 and later vehicles, and also a check of the converter, inlet restrictor, and Plumbtesmo for 1980 and later vehicles. To investigate the effectiveness of Houston's program, the 1985 tampering data for the components

and model years covered can be compared to similar data from the 1983 survey in Houston (see Table 14). The data presented in Table 14 is from all vehicles surveyed in Houston, including any non-Harris County vehicles that were surveyed. It is obvious that Houston's ATP program has noticeably reduced tampering for almost every component covered. As more antitampering-only programs are enacted nationwide, their effectiveness will be carefully evaluated.

9. Correlation between Tampering and Idle Emissions

As was mentioned previously, vehicles which are subject to an I/M program must meet specific idle emissions cutpoints. To assess the relationship between tampering and fuel switching and idle failure rates, the idle emissions from vehicles have been tested against the cutpoints established by the I/M program where they were sampled. Vehicles in non-I/M areas were tested against the cutpoints specified by the New Jersey I/M program. The cutpoints for each I/M area are listed in Appendix C.

The results of the idle tests are presented in Figure 12 for vehicles in the various tampering and fuel switching categories. Only 14% of the surveyed vehicles that were free of tampering and fuel switching failed an idle test, while 65% of the tampered and fuel switched vehicles failed that test. These results indicate that a substantially larger

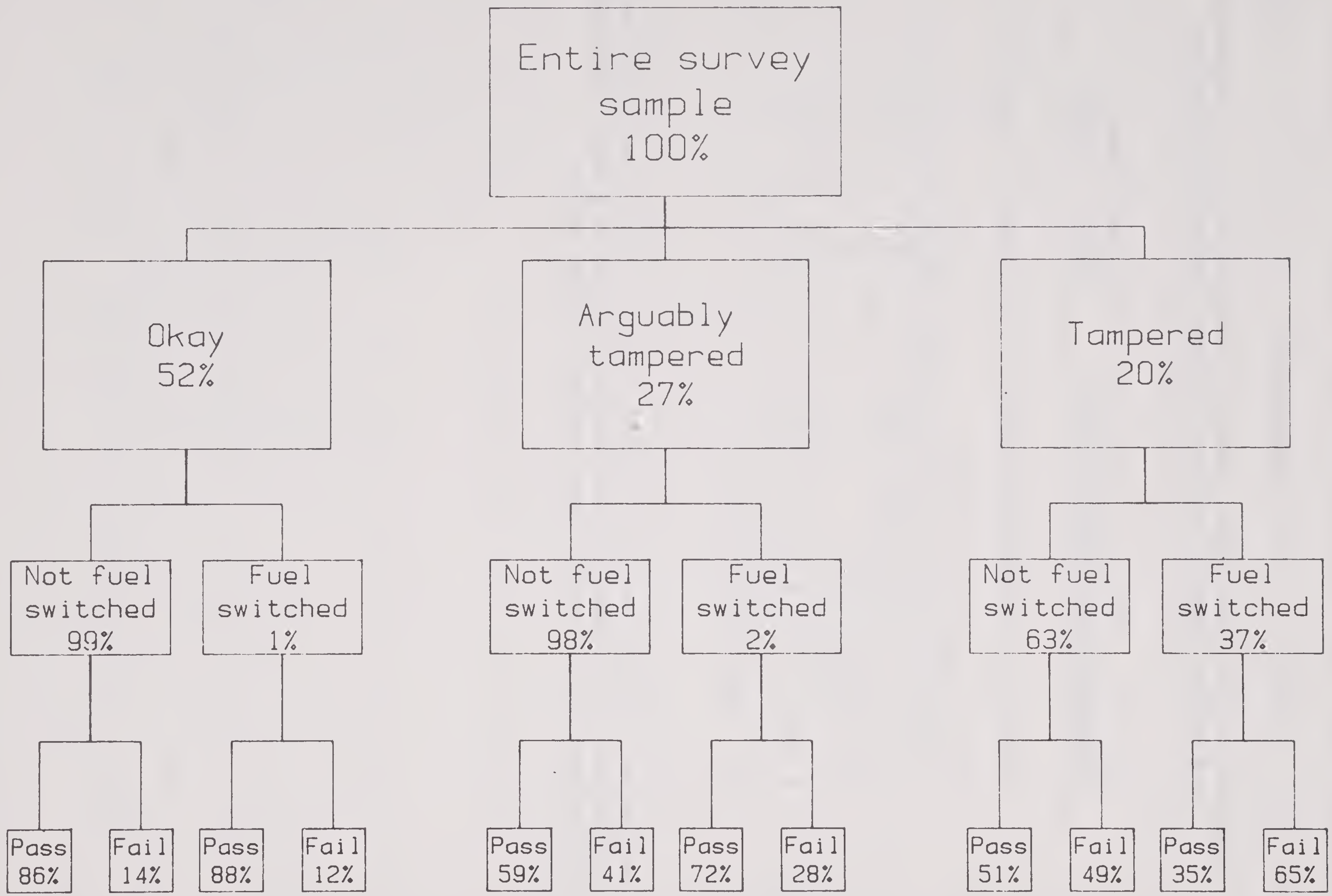
TABLE 14

Comparison of Tampering Rates in Houston* for Components and Model Years covered by Antitampering Program

Component and Model Years	Survey Year 1983	Survey Year 1985
Catalytic Converter 1980+	6%	2%
Inlet Restrictor 1980+	1	1
Positive Plumbtesmo 1980+	7	2
PCV System 1975+	9	5
Evaporative System 1975+	8	4
Air Pump System 1975+	9	8

* averages include any non-Harris County vehicles that were surveyed. The 1985 rates for Harris County vehicles only are equal to or lower than those listed above

Figure 12
Distribution of Survey Sample Among Tampering*, Fuel Switching, and Idle Test Categories



*excludes malfunctioning vehicles (1% of total)

proportion of tampered and fuel switched vehicles than of okay vehicles fail an idle test at typical I/M cutpoints. This is partly due to the tendency for tampered vehicles to have misadjusted carburetors, as is shown in Figure 13. This Venn diagram shows that 73% of the tampered vehicles with conventional carburetors also had missing sealed plugs or limiter caps. It must be noted from Figure 12, however, that 35% of the tampered and fuel switched vehicles were still able to pass the idle test.

Table 15 shows the percentage of vehicles that failed the idle emissions test for each vehicle condition. The failure rates are listed for the entire survey, as well as in two model year groupings representing "old" technology (1975-1980) and "new" technology (1981+) vehicles. "New" technology signifies closed loop emissions control, which came into widespread usage in 1981 model year vehicles.

The overall failure rate for HC from tampered vehicles was nearly four times greater than for okay vehicles, and was three times greater for CO emissions. Over 40% of the vehicles that either had been fuel switched or had their catalysts removed also exceeded HC and CO limits. Conversely, nearly 60% of the vehicles with missing catalysts or classified as fuel switched were still able to pass an idle emissions test. Interestingly, a significant number of arguably tampered vehicles also produced excess idle emissions. Since the

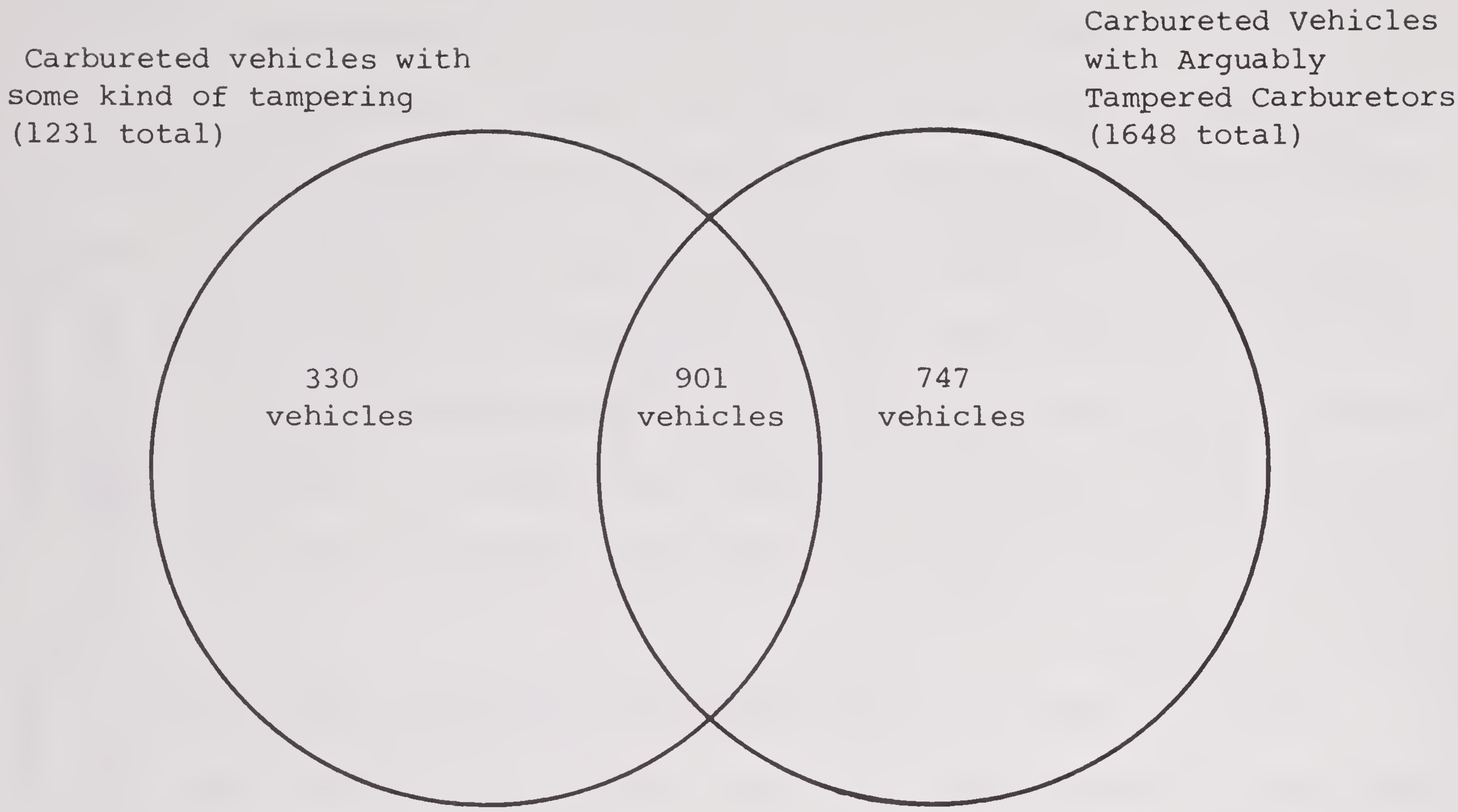


Figure 13. Overlap of Tampering and carburetor misadjustment among conventionally carbureted vehicles - 1985 survey.

majority of arguable tampering involves idle speed limiter caps and sealed plugs, the high failure rate demonstrates the adverse idle emissions impact of improperly adjusted carburetors.

The effectiveness of idle emissions testing on "new" technology vehicles can also be seen in Table 15. Idle emissions testing is considerably more effective in identifying tampering on 1980 and older vehicles than on 1981 and newer vehicles. It is particularly interesting that only one-quarter of the 1981 and newer vehicles surveyed which had missing catalysts or had been fuel switched would fail an idle emissions test. This suggests that idle emissions testing may not be an effective strategy for identifying tampering and fuel switching among "new" technology vehicles, since many vehicles with closed loop systems are able to produce low idle emissions even with a missing or inactive catalyst. The Agency has consistently advised I/M programs not to rely on idle emissions testing for these vehicles for this reason.

The mean idle emissions for tampered and okay vehicles are presented in Table 16 by program type. The mean idle emissions from tampered vehicles were considerably higher than from okay vehicles. Overall, HC emissions from tampered vehicles were more than six times greater on average than for okay vehicles, while CO emissions were almost seven times greater. The means for non-I/M areas were higher than for I/M-only and I/M + ATP areas.

TABLE 15

Idle Test Failure Rates (percent) by Pollutant and Vehicle Condition

Vehicle Condition	Failure Rate (%) by Pollutant for Model Years listed					
	1975-80		1981+		Overall	
	HC	CO	HC	CO	HC	CO
Okay	19	16	8	7	10	8
Arguably Tampered	31	38	15	16	26	31
Tampered	42	45	27	19	39	40
Catalyst Removed or Fuel Switched	45	49	26	21	42	44

TABLE 16

Mean Idle Emissions by Vehicle Condition

Survey Sites	HC emissions(ppm) Tampered	HC emissions(ppm) Okay	CO emissions(%) Tampered	CO emissions(%) Okay
non-I/M	341.0	51.9	3.0	0.3
I/M only	243.9	41.8	2.2	0.3
I/M + ATP	238.3	40.3	1.9	0.3
ATP-only	306.4	36.5	3.2	0.3
OVERALL	296.8	45.9	2.6	0.3

To investigate the relationship between I/M programs and idle emissions, the emissions from okay and tampered vehicles in each program type can be compared (see Table 16). The data indicates that idle HC emissions from okay vehicles in I/M areas were 19% lower than from vehicles in non-I/M areas. There was no difference in this survey between idle CO emissions from I/M areas and those from non-I/M areas. The presence of an antitampering program further lowered idle HC and CO emissions from okay vehicles. Idle HC and CO emissions from tampered vehicles were 28% and 27% lower, respectively, in I/M-only areas than in non-I/M areas, suggesting that I/M programs may reduce idle emissions from vehicles for which tampering is not successfully deterred.

B. FUEL SWITCHING

1. Fuel Switching Indicators and Overlap

Fuel switching is more easily defined than measured, since no single indicator can accurately determine its prevalence. Since 1981 the surveys have used a combination of three indicators to measure fuel switching more accurately: a tampered fuel filler inlet restrictor, a positive Plumbtesmo test for lead deposits in the tailpipe, and a gasoline lead concentration of more than 0.05 gram per gallon (gpg). Of these three indicators, only a tampered inlet restrictor is also considered tampering, and as such is used to calculate

both tampering and fuel switching rates. Since false positive indications should be extremely rare for these measures, the percentage of vehicles with at least one positive indicator is a reasonable minimum estimate of fuel switching.

The presence of any of these three indicators suggests that a given vehicle has been misfueled; their absence, however, does not rule it out. For example, fuel samples could only be obtained from 83% of the unleaded vehicles surveyed, limiting the scope of this variable. A vehicle misfueled repeatedly with leaded gasoline may also have little detectable lead in its fuel tank due to subsequent proper fueling. Similarly, a vehicle with an untampered fuel filler inlet restrictor may have been fueled at a leaded pump equipped with a smaller nozzle, or by using a funnel or similar device. The tailpipe lead test, due to the difficulties of field administration, may also fail to identify misfueling, and older vehicles may have had their tailpipes replaced since last operated on leaded fuel. As the lead phasedown program lowers lead levels in leaded gasoline, the incidence of false negative Plumbtesmo results may increase. The uncertainty in these measures, then, is always toward underestimating the number of vehicles misfueled.

The limitations of the fuel switching indicators can be seen in their incomplete overlap. The results from these indicators would be expected to overlap significantly, since

they are three indicators of the same phenomenon. This has not held true, however, in the 1985 survey or in previous surveys. The Venn diagram (Figure 14) illustrates the degree of overlap in the 1985 results. For example, only 77% of the vehicles having leaded fuel in their tank also registered a positive Plumbtesmo test. Additionally, only 45% of the vehicles with tampered inlet restrictors actually had leaded gasoline in their tanks at the time of the survey. The incomplete overlap reflects the limitations of each indicator as well as the different aspects of fuel switching each indicator identifies.

2. Fuel Switching Rates

Of the vehicles requiring unleaded fuel, 9% were identified as misfueled by at least one of the indicators discussed above. The fuel switching incidence by survey site and program type is listed in Table 17. Non-I/M sites had the highest fuel switching rate (12%), followed by I/M + ATP areas and I/M-only areas. The prevalence of each fuel switching indicator in non-I/M areas is approximately double that found in areas with control programs.

Tables 18 and 19 compare the fuel switching rates from the 1985 survey with those from previous surveys. As the tables indicate, the data from this survey show a general pattern of decline in fuel switching. Since such a pattern could result from the selection of sites surveyed this year, strong conclusions must await the data from subsequent surveys.

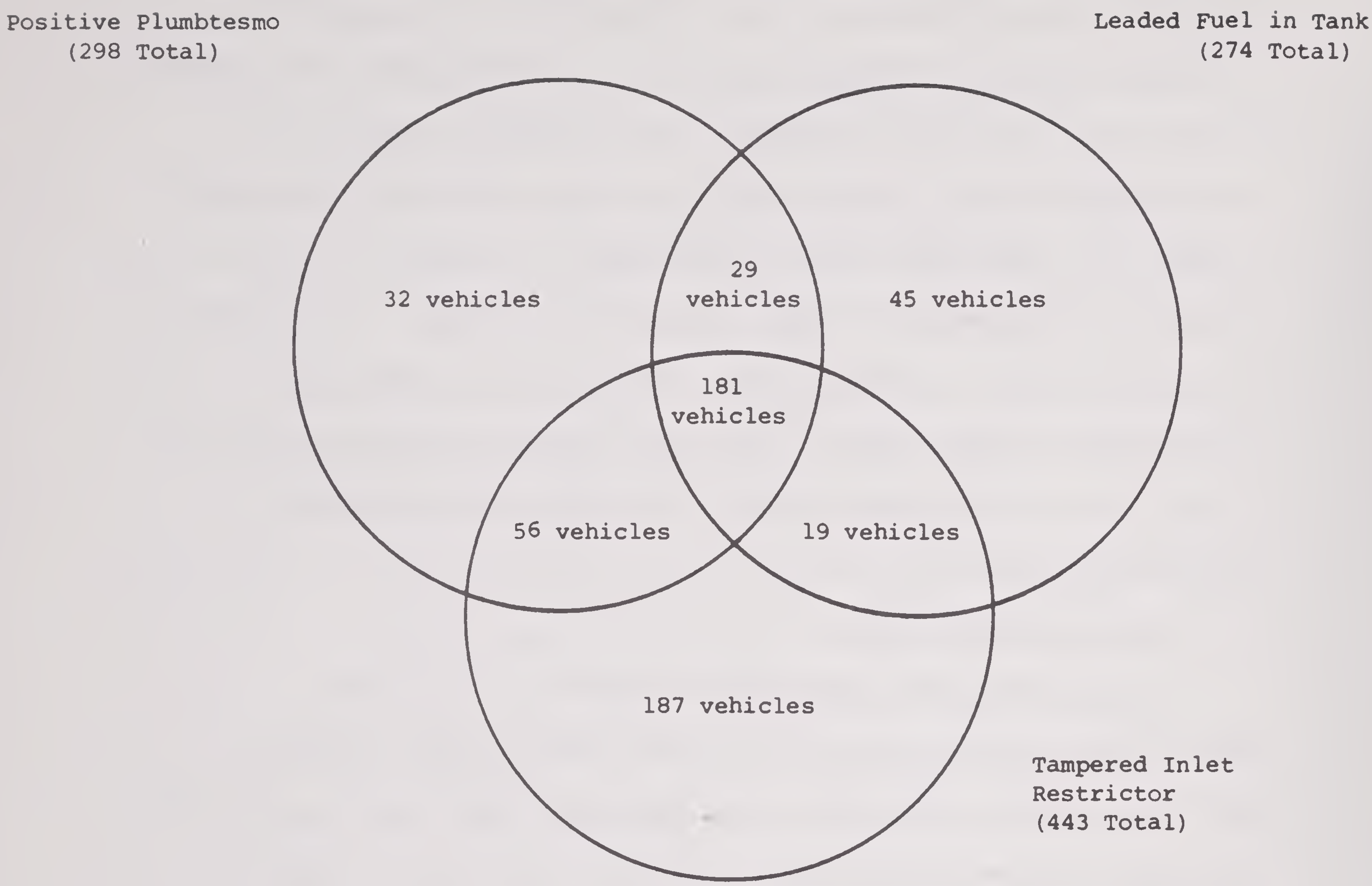


Figure 14. Overlap of fuel switching indicators among unleaded vehicles - 1985 Survey.

TABLE 17

Fuel Switching Rates among Unleaded Vehicles by Site and Indicator - 1985 Survey

Survey Location	Leaded Fuel in Tank(%)	Tampered Inlet Restrictor(%)	Positive Plumbtesmo (%)	$\geq$1 Positive Indicators (%)
		Non-I/M Areas		
Kansas City, MO	6	9	6	10
Kansas City, KS	9	10	7	12
Raleigh, NC	11	11	9	14
Portland, ME	2	4	1	5
Cleveland, OH	3	7	4	8
Baton Rouge, LA	13	17	14	21
Albuquerque, NM	5	9	5	11
ALL NON-I/M SITES	7	9	7	12
		I/M Only Areas		
Louisville, KY	6	8	6	10
Wilmington, DE	1	3	2	5
Philadelphia, PA	1	2	1	3
ALL I/M ONLY SITES	3	5	3	6
		I/M + ATP Areas		
Fresno, CA	2	9	1	9
Charlotte, NC	3	5	3	6
N. Virginia	2	4	1	4
Long Island, NY	5	4	4	7
ALL I/M+ATP SITES	3	6	2	7
HOUSTON, TX (ATP ONLY)	4	5	5	7
ALL SITES	5	7	5	9

TABLE 18

Fuel Switching Prevalence among Unleaded Vehicles in I/M and non-I/M Areas

Survey Year	Fuel Switching Rate (%) non-I/M	I/M only	I/M + ATP	Overall
1978*	4	NS	NS	4
1979*	12	3	NS	9
1981**	16	NS	NS	16
1982	15	7	2*	11
1983	17	12	5	14
1984	19	10	8	14
1985	12	6	7	9

*Plumbtesmo test not used.
**1981 survey was of limited scope, covering only two sites and 399 vehicles.
NS: None surveyed

TABLE 19

Fuel Switching Rates among Unleaded Vehicles by Indicator and Survey Year

Survey Year	Leaded Fuel in Tank(%)	Tampered Inlet Restrictor(%)	Positive Plumbtesmo(%)	≥1 Positive Indicators(%)
1978	4	3	*	4
1979	10	4	*	9
1981	7	6	8	16
1982	6	6	7	11
1983	7	7	10	14
1984	8	10	9	14
1985	5	7	5	9

*Plumbtesmo test not used.

Table 20 presents the combined tampering and fuel switching rates for the 1985 survey. The percentage of vehicles that were tampered or fuel switched was 21%, only 1% higher than the tampering rate alone. The substantial overlap between the tampering or fuel switching rate and the tampering rate alone results mainly from the inlet restrictor tampering rates being used to calculate both values. Table 20 also demonstrates that approximately half of all tampering and fuel switching is composed of vehicles in the catalyst removed or fuel switched category. This indicates the very serious nature of most tampering.

3. Fuel Switching by Vehicle Type

As was reported previously, the fuel switching rates for trucks was considerably higher than for passenger cars - 13% vs. 8% (Table 1). The filler neck restrictor tampering rates were also higher for trucks than for passenger cars (Table 1).

4. Fuel Switching and Vehicle Age

Table 21 correlates vehicle age and model year with fuel switching rates for the 1978-1985 surveys. This method of analysis is identical to the one used earlier to compare tampering rates across model years and vehicle ages. Analyzing Table 21 diagonally shows that the rate of fuel switching

TABLE 20

Combined Tampering and Fuel Switching Rates - 1985 Survey

Survey Location	Catalyst-equipped vehicles with catalysts removed or fuel switched (%)	Unleaded vehicles either tampered or fuel switched (%)
	Non-I/M Areas	
Kansas City, MO	12	22
Kansas City, KS	12	27
Raleigh, NC	15	20
Portland, ME	6	14
Cleveland, OH	11	23
Baton Rouge, LA	20	33
Albuquerque, NM	11	25
ALL NON-I/M SITES	12	23
	I/M-only Areas	
Louisville, KY	10	24
Wilmington, DE	6	15
Philadelphia, PA	3	14
ALL I/M-ONLY SITES	6	17
	I/M + ATP Areas	
Fresno, CA	10	22
Charlotte, NC	6	19
N. Virginia	5	15
Long Island, NY	9	22
ALL I/M + ATP SITES	8	20
HOUSTON, TX (ATP ONLY)	9	19
ALL SITES	10	21

TABLE 21

Percentage of Fuel Switching (and Sample Size) among Unleaded Vehicles by Model Year and Vehicle Age at Time of Survey*

Model Year	Year of Vehicle Life										
	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh
1985	1(816)										
1984	3(462)	2(1001)									
1983	5(182)	4(471)	1(710)								
1982	5(250)	6(226)	6(465)	3(621)							
1981	9(57)	7(444)	9(205)	8(457)	5(607)						
1980		11(62)	8(447)	8(210)	11(487)	9(562)					
1979	6(328)		16(55)	12(432)	19(269)	18(455)	15(636)				
1978	2(296)	8(451)		18(74)	12(377)	15(221)	24(486)	19(527)			
1977		3(438)	9(428)		18(60)	13(283)	23(176)	27(357)	24(420)		
1976			6(388)	15(316)		37(49)	14(249)	21(147)	24(314)	27(328)	
1975				6(255)	14(213)		30(20)	17(146)	24(82)	26(174)	34(179)

*Plumbtesmo not used in 1978 and 1979 surveys.

increased with vehicle age in every survey taken. A similar though less pronounced pattern can be seen when the data is analyzed within model years (horizontally) or within vehicle age groups (vertically).

5. Catalyst Tampering and Fuel Switching

Consumers and mechanics remove catalytic converters for a number of reasons, but much of their motivation is related to fuel switching. The vehicle owner may remove the catalytic converter either prior to misfueling, or after some misfueling if the vehicle's driveability has been adversely affected by a catalyst damaged from the repeated misfueling. The data from this survey cannot be used to distinguish between these two situations, but can be used to examine the extent to which these types of abuse occur in conjunction.

Of the catalyst-equipped vehicles surveyed, 10% were either catalyst tampered or fuel switched (Table 20). The rates in non-I/M, I/M-only, and I/M + ATP areas were 12%, 6%, and 8%, respectively.

Figure 15 depicts the degree of overlap between catalyst removal and fuel switching. Vehicles with catalyst tampering exclusive of fuel switching were relatively uncommon -- only one-third of the catalyst tampered vehicles were not fuel switched. Fuel switching, however, is not always accompanied by catalyst removal, since 61% of the fuel switched vehicles still had their catalysts.

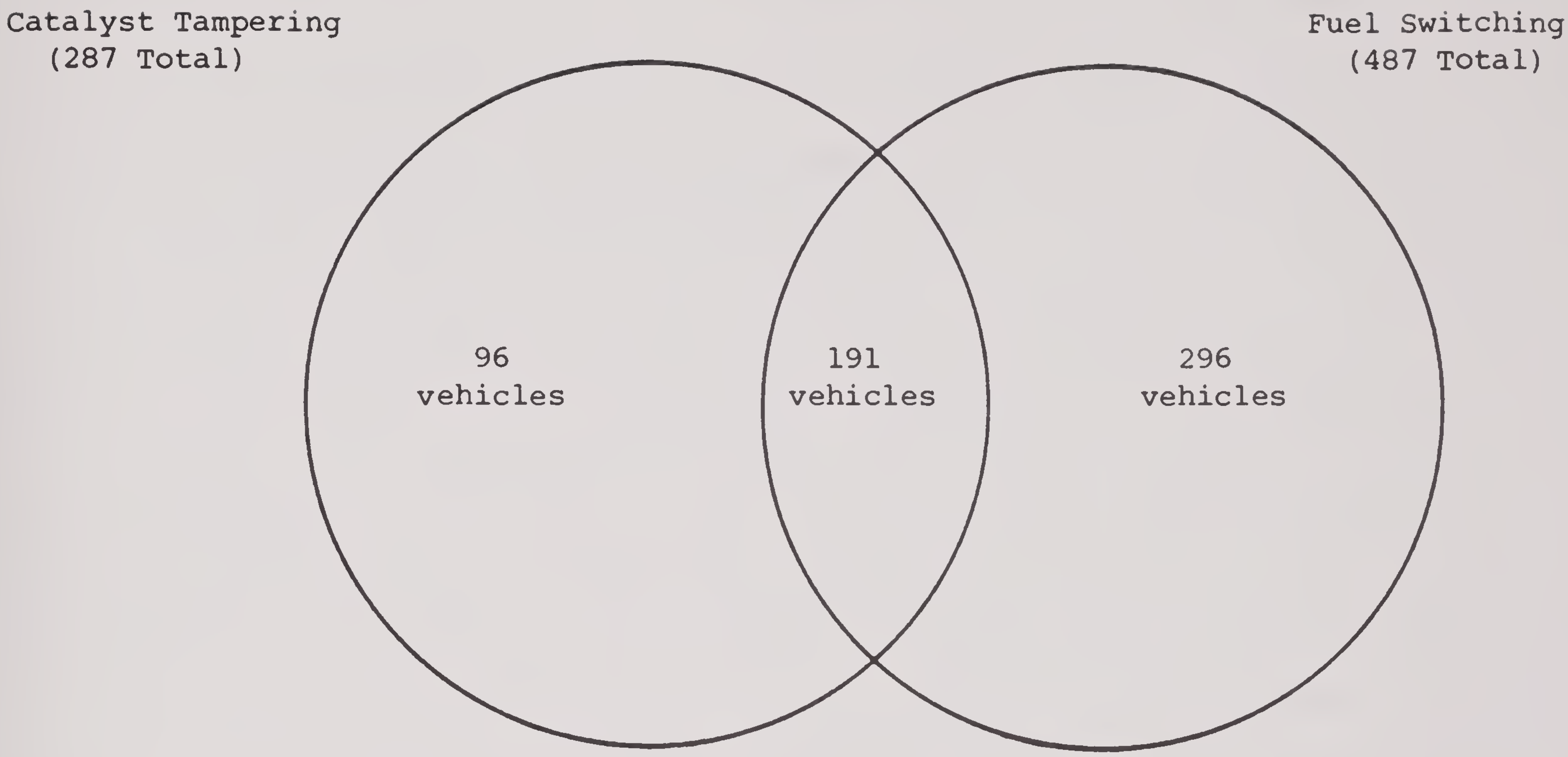


Figure 15. Overlap of catalyst tampering and fuel switching among catalyst-equipped vehicles - 1985 Survey.

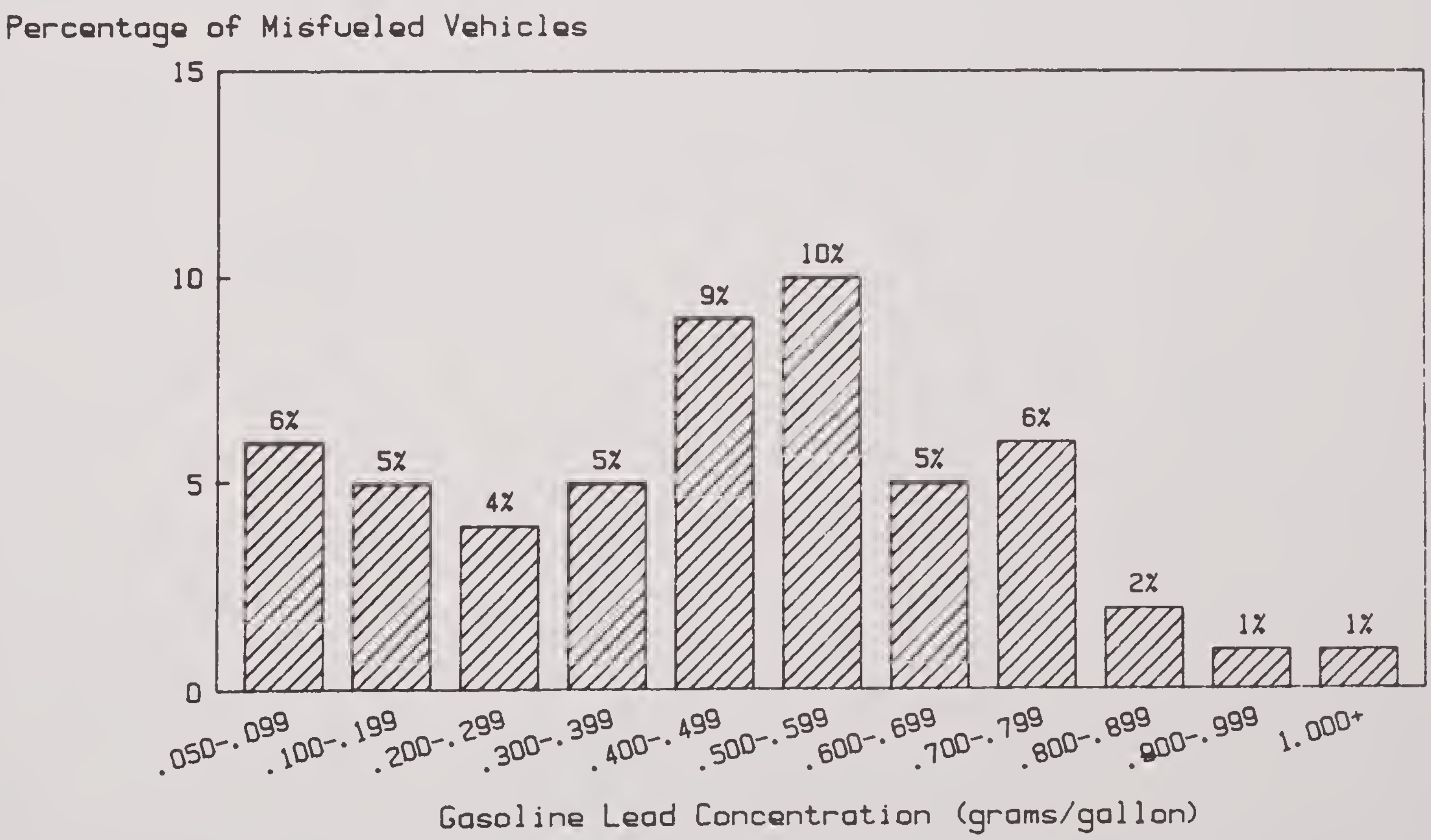


Figure 16. Lead concentrations in fuel sampled from misfueled vehicles.

6. Gasoline Lead Concentrations

Of the vehicles identified by any of the three indicators as misfueled, 46% had only trace amounts of lead (less than 0.05 gpg) in their gasoline when inspected. These vehicles, then, were identified as fuel switched by a tampered filler restrictor and/or a positive Plumbtesmo test. Figure 16 presents the distribution of lead concentrations of 0.05 gpg or more in misfueled vehicles. The impact of lead phasedown can be dramatically seen when Figure 16 is compared to similar data from the 1984 survey. In the 1984 survey 39% of the misfueled vehicles had a gasoline lead concentration in excess of 1.0 gpg, compared to 1% in 1985. The distribution of lead concentrations in 1985 is centered on the 0.4-0.6 gpg range, which coincides with the interim lead limit of 0.5 gpg in effect between July, 1985 and December, 1985.

APPENDIX A

RELEVANT PORTIONS OF THE CLEAN AIR ACT

Section 203(a)(3): The following acts and the causing thereof are prohibited --

(A) for any person to remove or render inoperative any device or element of design installed on or in a motor vehicle or motor vehicle engine in compliance with regulations under this title prior to its sale and delivery to the ultimate purchaser, or for any manufacturer or dealer knowingly to remove or render inoperative any such device or element of design after such sale and delivery to the ultimate purchaser; or

(B) for any person engaged in the business of repairing, servicing, selling, leasing, or trading motor vehicles or motor vehicle engines, or who operates a fleet of motor vehicles, knowingly to remove or render inoperative any device or element of design installed on or in a motor vehicle or motor vehicle engine in compliance with regulations under this title following its sale and delivery to the ultimate purchaser.

APPENDIX B

SURVEY AND DATA RECORDING PROCEDURES

1. Explanation of Survey Forms

The forms on the following pages were used for recording the survey data in the field. The forms were forced choice to ensure coding consistency, and were designed to facilitate direct data entry. The following codes were used to record data for the major system components on the data sheets:

0 - Not originally equipped

1 - Functioning properly

2 - Electrical disconnect

3 - Vacuum disconnect

4 - Mechanical disconnect

5 - Incorrectly routed hose

6 - Disconnect/Modification

7 - Missing item

8 - Misadjusted item

9 - Malfunctioning

A - Stock equipment

B - Non-stock

D - Add on equipment

Y - Yes

Z - No

Additional codes were used for those components which could not be classified into the above categories. A brief description of each data entry follows.

1985 TAMPERING SURVEY - PART A (UNDERHOOD)

1 ID NUMBER (4)

5 I/M STICKER (dates of last inspection) MO YR (8)

9 DISPLACEMENT (cubic inches or liters) (12)

13 MODEL YEAR (14)

**NOTE: if engine fam. is missing or illegible, copy all but the last 6 digits of the VIN. <u>DO NOT COPY SERIAL NUMBER PORTION OF VIN.</u>

15 ENGINE FAMILY (25)

26 VIN (if engine family not available) (36)

37 ORIGINALLY CATALYST EQUIPPED?
<u>FROM STICKER UNDER HOOD OR DRIVER'S DOOR POST</u>
- Y- Yes
- Z- No
- X- Can't tell (no sticker, not readable, or not mentioned)

38 AIR CLEANER
- A- Stock
- B- Non-Stock
- 7- Missing item

39 HEATED AIR INTAKE
- 0- Not orig. equipped
- 1- Funct. properly
- 3- Vacuum disconnect
- 4- Mech. disconnect
- 7- Missing item (stovepipe hose)
- 9- Malfunct. item (vac. override)
- B- Non-stock(custom air cleaner)

40 PCV SYSTEM
- 1- Funct. properly
- 3- Vacuum disconnect
- 4- Mech. disconnect (fresh air hose)
- 7- Missing item
- B- Non-stock(Inc. fuel economy devices)

41 TURBOCHARGER
- 0- Not orig. equipped
- A- Stock
- B- Non-stock
- D- Add-on

42 EVAP. CONTROL SYSTEM
- 1- Funct. properly
- 3- Vacuum discon. (carb. line)
- 4- Mech. discon. (tank line)
- 5- Incorr. routed hose
- 7- Missing item
- 9- Malfunct. item (air cleaner unsealed)

43 ASPIRATED AIR INJECTION SYSTEM
- 0- Not orig. equipped (if conventional system or none)
- 1- Funct. properly
- 4- Mech. disconnect
- 7- Missing item
- 9- Malfunctioning

44 AIR PUMP BELT (if Aspir., code "0")
- 0- Not orig. equip.
- 1- Funct. properly
- 7- Missing item
- 8- Misadjusted item (loose)

45 AIR PUMP SYSTEM (incl. valve)
- 0- Not orig. equipped (if aspirated or none)
- 1- Funct. properly
- 4- Mech. disc. (other than belt removal)
- 7- Missing item
- 9- Malfunctioning (frozen)

46 EXHAUST MANIFOLD
- A- Stock
- B- Non-stock

47 OXYGEN SENSOR
- 0- Not orig. equipped
- 1- Functioning properly
- 2- Electrical disconnect
- 4- Mech. disc. (unscrewed)
- 7- Missing item

48 CARBURATOR TYPE
- S- Sealed
- F- Fuel Injection
- A- Stock
- B- Non-stock

49 LIMITER CAPS
- 0- Not orig. equipped (fuel injection)
- 1- Funct. properly
- 4- Mech. disconnect (tabs broken or bent)
- 7- Missing item
- 8- Misadjusted (sealed plugs removed)

50 EGR CONTROL VALVE
- 0- Not orig. equipped
- 1- Funct. properly
- 3- Vacuum disconnect
- 4- Mech. disconnect
- 7- Missing item

51 EGR SENSOR (coolant, back-pressure, etc.)
- 0- Not orig. equipped
- 1- Funct. properly
- 3- Vacuum disconnect
- 5- Incorr. routed hose
- 7- Missing item

52 COMPUTER SYSTEM & RELATED SENSORS
- 0- Not orig. equipped
- 1- Funct. properly
- 6- Disconnect/Modification (explain)

1985 TAMPERING SURVEY - PART B (REAR)

1 ID NUMBER (4)

5 MAKE (write out) (8)

9 MODEL (write out) (12)

13 VEHICLE TYPE
- C- Car
- T- Truck (includes vans)

14 LICENSE PLATE (State) (15)

16 IDLE HC (PPM) (19)

20 IDLE CO (%) (22)

23 ODOMETER (Thou.) (25)

26 DASH LABEL
- 0- Not orig. equipped
- 1- Funct. properly (present)
- 7- Missing item

27 CATALYTIC CONVERTER
- 0- Not orig. equipped
- 1- Funct. properly (present)
- 7- Missing item

28 EXHAUST SYSTEM
- A- Stock
- B- Non-Stock

29 EXHAUST SYSTEM INTEGRITY
- 1- Funct. properly (no obvious leaks)
- 9- Malfunctioning (leaks evident)

30 TANK CAP
- 1- Funct. properly
- 7- Missing item
- 9- Malfunctioning

31 TANK LABEL
- 0- Not orig. equipped
- 1- Funct. properly (present)
- 7- Missing item

32 FILLER NECK RESTRICTOR
- 0- Not orig. equipped
- 1- Funct. properly
- 4- Mech. disc. (widened)
- 7- Missing item

33 PLUMBTESMO
- P- Positive
- N- Negative

34 FUEL SAMPLE
- Y- Yes
- Z- No

leave blank

35 FUEL DATA (38)

Form A - Underhood

1-4 ID Number - Vehicles are numbered sequentially as they are inspected. This number is preceded by a site identifying letter.

5-8 Month and year of last I/M inspection (left blank if vehicle is licensed in non-I/M area).

9-12 Displacement - as recorded on the underhood emission label.

13-14 Vehicle Model year

15-25 Engine Family - as recorded on the underhood emission label.

26-36 Non-serial number portion of VIN - as recorded on the driver's side of the dash under the windshield or the driver's door post. The VIN is recorded only if the engine family can not be determined.

37 Originally Catalyst Equipped - as recorded on the underhood emission label or the driver's door post.

38 Air Cleaner - is coded 'A', 'B', or '7'.

39 Heated Air Intake - provides warm air to the carburetor during cold engine operation. The heated air intake is coded '0', '1', '3', '4', '7' (stovepipe hose), '9' (vacuum override), or 'B' (custom air cleaner).

40 Positive Crankcase Ventilation (PCV) system - prevents crankcase emissions by purging the crankcase of blow-by gases which leak between the piston rings and the cylinder wall in the combustion chamber under high pressures. The PCV system is coded '1', '3', '4' (fresh air hose), '7', or 'B' (includes fuel economy devices).

41 Turbocharger - coded '0', 'A', 'B', or 'D'.

42 Evaporative Control System (ECS) - controls vapors from the fuel tank and carburetor. Some systems have two lines: from the fuel tank to the canister, and from the canister to the carburetor or air cleaner (for purging the canister). Other systems have a third line connected to the carburetor. The ECS is coded '1', '3' (carburetor line), '4' (tank line), '5', '7', or '9' (air cleaner unsealed).

Air Injection System - extends the combustion process into the engine's exhaust system by injecting fresh air into the exhaust ports, lowering exhaust emissions while still maintaining proper vehicle performance.

Two types of air injection systems are currently used. One type uses a belt-driven air pump to direct air through a control valve and into the exhaust manifold. The other type is a Pulse Air Injection Reaction (PAIR) system, which uses an aspirator commonly located in the air cleaner to supply air to the exhaust manifold.

43 PAIR - coded '0' (if air pump system or none), '1', '4', '7', or '9'.

44 Air Pump Belt - is coded '0' (if PAIR), '1', '7', or '8' (loose belt).

45 Air Pump System - for the purposes of this variable, consists of the air pump and control valve and is coded '0' (if a PAIR or none), '1', '4' (excluding belt removal), '7', or '9'.

46 Exhaust Manifold - coded 'A' or 'B'.

47 Oxygen Sensor - Controls the air-fuel mixture going into the engine of vehicles equipped with three-way catalytic converters. The sensor is coded '0', '1', '2', '4' (unscrewed), or '7'.

48 Carburetor Type - is coded 'S' (sealed plugs covering mixture adjustment), 'F' (fuel injection), 'A', or 'B'.

49 Limiter Caps - plastic caps on the idle mixture screws to limit carburetor adjustments. The limiter caps are coded '0', '1', '4' (tabs broken or bent), '7', or '8' (sealed plugs removed).

Exhaust Gas Recirculation (EGR) System - directs a portion of the exhaust gases back into the cylinders to reduce NO_x emissions in the exhaust gas. The standard EGR configuration consists of a vacuum line from the carburetor to a sensor (used to detect engine operating temperature to activate the EGR valve), and another vacuum line from the sensor to the EGR valve.

50 EGR Control Valve - coded '0', '1', '3', '4', or '7'.

51 EGR Sensor - coded '0', '1', '3', '5', '7'.

52 Computer Systems and Related Sensors - computerized engine and emissions control system which receives input from various sensors for engine condition information, and constantly adjusts the air/fuel ratio, distributor, and emissions devices for optimum economy, driveability, and emissions. The system

is coded '0', '1', or '6'. This variable includes the entire computer system except for the oxygen sensor, which is coded separately (see variable #47, Form A).

Form B - Rear

1-4 ID Number - Same as on Form A.

5-8 Make

9-12 Model

13 Vehicle Type - coded as follows: C = car, T = truck

14-15 License Plate - State abbreviation

16-19 Exhaust gas HC concentration (in ppm) at curb idle.

20-22 Exhaust gas CO concentration (in percent) at curb idle.

23-25 Odometer - mileage in thousands

26 Dash Label - displays the fuel required and is coded '0', '1', or '7'.

27 Catalytic Converter - oxidizes the HC and CO to water and CO_2 in the exhaust gas. Later model catalysts also reduce oxides of nitrogen. The converter is coded '0', '1', or '7' (entire catalyst canister removed).

28 Exhaust System - if as originally equipped an 'A' is coded. If non-stock a "B' is coded.

29 Exhaust System Integrity - the condition of the exhaust system is coded '1' (no obvious leaks) or '9' (leaks evident).

30 Tank Cap - seals the fuel tank during normal operating conditions and is coded '1', '7', or '9' (loose cap).

31 Tank Label - displays required fuel and is coded '0', '1', or '7'.

32 Filler Neck Inlet Restrictor (unleaded vehicles only) - The restrictor is designed to prevent the introduction of leaded fuel into a vehicle requiring unleaded fuel. It is coded '0', '1', '4' (widened), or '7'.

33 Plumbtesmo - Plumbtesmo paper is used to check for the presence of lead in vehicle exhaust pipes. A positive indication is coded as 'Y' and a negative as 'Z'.

34 Fuel Sample - indicates if inspector was able to obtain fuel sample for later lead analysis ('Y' or 'Z').

2. <u>Classification Of Component Conditions</u>

The table below was used to classify the various system components as 'tampered', 'arguably tampered', or 'malfunctioning'. Only those codes which are applicable to a given component are listed. Codes for 'not originally equipped' and 'functioning properly' are not included in this table. Refer to Appendix B, Part 1 for an explanation of the codes.

	Codes from form								
Component/system	2	3	4	5	6	7	8	9	B
Dash Label						A			
Tank Cap						A		M	
Tank Label						A			
Filler Neck Restrictor			T			T			
Catalytic Converter						T			
Oxygen Sensor	T		T			T			
PCV System		T	T			T			T
Heated Air Intake		T	A			A		M	T
Evaporative Control System		T	T	T		T		M	
Aspirated Air Injection System			T			T		M	
Air Pump Belt						T	M		

T = tampered
A = arguably tampered
M = malfunctioning

Component/system	Codes from form								
	2	3	4	5	6	7	8	9	B
Air Pump System			T			T		M	
EGR Control Valve		T	T			T			
EGR Sensor		T		T		T			

T = tampered
A = arguably tampered
M = malfunctioning

3. Fuel Sample Collection and Labeling Procedures

A fuel sample was taken from each vehicle requiring unleaded fuel. These samples were collected in two-ounce bottles with a hand-operated fuel pump. Once the sample was drawn, the fuel was replaced with an equivalent amount of unleaded fuel if the driver requested, and the pump was flushed with unleaded fuel.

Each bottle was identified with an adhesive label that had the vehicle identifying survey number on it. The vehicle identifying number was the first entry on the data forms described in Part 1 of Appendix B.

Prior to shipment from the field, a sample tag with the same identifying number was attached to each bottle. The bottles were packed, labeled, and shipped to NEIC Chemistry Branch according to the shipper's requirements and the NEIC Policy and Procedures Manual.

4. Plumbtesmo Application

1) Clean a portion of the inside of the tailpipe large enough for the test paper by wiping it out with a paper towel or cloth. This may be necessary to remove soot deposits which might mask the color change.

2) Moisten the Plumbtesmo paper with distilled water and immediately* press firmly against the surface to be tested for approximately thirty seconds. If the tailpipe is hot you may wish to clamp the test paper in the tailpipe using a clean clamp.

*Note: The Plumbtesmo paper must be applied during the time that the paper is yellow for the reaction to take place. After approximately 15 seconds the yellow color disappears and the paper is no longer effective. Excess water also interferes with the reaction.

Care must be taken to avoid contamination of the test paper. If a person has recently handled a test paper with a positive reaction, some lead or reactive chemical may have been transferred to their fingers. Subsequently handling a clean test paper may cause contamination.

3) After removing the test paper, determine whether a color change has occurred. Red or pink coloration indicates the presence of lead.

5. Field Quality Control/Assurance

Reference and calibration gases were used to ensure the accuracy of the emissions analyzer. Horiba gases certified by RTP were used as reference gases. Two cylinders of reference gas were used to validate the accuracy of the calibration gases before they were taken to the field on each survey.

Three calibration gases (Horiba) were used. These gases were a mixture of CO and HC in nitrogen and were used to check the instrument at least three times daily. These calibration gases were certified by the manufacturer and the RTP reference gases. Their approximate compositions were:

8% CO
1560 ppm HC (Hexane equivalent)

4% CO
827 ppm HC (Hexane equivalent)

1.6% CO
320 ppm HC (Hexane equivalent)

APPENDIX C

EMISSION CUTPOINTS FOR I/M AREAS

The table below lists the emission cutpoints used in 1985 by the I/M areas covered in the 1985 tampering survey. The cutpoints for pre-1975 vehicles are not included, since these vehicles were not surveyed.

Survey Site	Model Year	Emissions Cutpoints CO (%)	HC (ppm)
New York City Metro Area	1975-77	5.7	700
	1978	4.3	500
	1979	3.0	400
	1980	2.7	330
	1981+	1.2	220
Wilmington, DE	1975-79	-	600
	1980+	-	235
Philadelphia, PA	1975-79	4.0	400
	1980	3.0	300
	1981+	1.2	220
Northern Virginia	1976-79	4.0	400
	1980	2.0	220
	1981+	1.2	220
Louisville, KY	1975-79	6.5	650
	1980	4.0	400
	1981+	1.2	220
Charlotte, NC	1975-78	5.0	-
	1979-80	3.0	-
	1981+	1.5	-
New Jersey	1975-80	3.0	300
	1981+	1.2	220

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